THE

# POPULAR SCIENCE MONTHLY.

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## THE GROWTH OF THE STEAM-ENGINE.[1]

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### III.

### THE NON-CONDENSING ENGINE, AND ITS APPLICATION IN THE LOCOMOTIVE.

45. The engines of Hero and Branca were, it will be remembered, non-condensing; but the first plan of a non-condensing engine that could have been made of any really practical use is given in the "*Theatrum Machinarum*," of Leupold, published in 1720. His sketch is copied in Fig. 23. It is stated by Leupold that this plan was sug-

[1] An abstract of "A History of the Growth of the Steam-Engine," to be published by D. Appleton & Co.

gested by Papin. It consists of two single-acting cylinders, *r s*, receiving steam alternately from the same steam-pipe through a "four-way-cock," and exhausting into the atmosphere. We find no evidence that this engine was ever built.

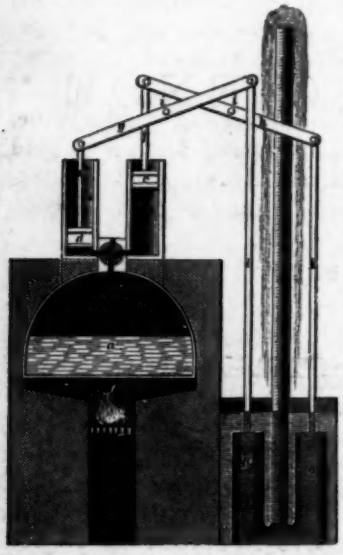

FIG. 23.—LEUPOLD'S PAPIN ENGINE, 1720.

When, during the last century, the steam-engine had so far been perfected that the possibility of its application to other purposes than the elevation of water had become generally recognized, the problem of its adaptation to the propulsion of carriages was attacked by many engineers and inventors.

As early as 1759, Dr. Robison, who was at the time a graduate of the University of Glasgow, and an applicant for an assistant professorship there, and who had made the acquaintance of the instrument-maker, James Watt, when visiting the workshop, called the attention of the latter, who was probably then more ignorant of the principles of the steam-engine than was the young student, to the possibility of constructing a carriage to be driven by a steam-engine, thus, perhaps, setting in operation that train of thoughtful experiment which finally earned for Watt his splendid fame.

46. Watt, at a very early period, proposed to apply his engine to locomotion, and contemplated using either a non-condensing engine, or an air-surface condenser. He actually included the locomotive-engine in his patent of 1784, and his assistant, Murdoch, in the same year, made a working-model locomotive which was capable of running at a rapid rate.

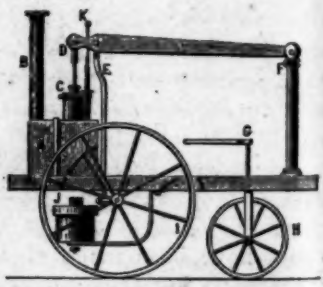

FIG. 24.—MURDOCH'S MODEL, 1784.

This model, now deposited in the Patent Museum, at South Kensington, London, had a flue-boiler, and a "grasshopper" engine. Its steam-cylinder was three-quarters of an inch in diameter, and had two inches stroke of piston (Fig. 24). The driving-wheels were nine and a half inches in diameter. It is reported to have run six to eight miles an hour, its little driving-wheels making from two hundred to two hundred and seventy-five revolutions per minute.

47. In 1765 that singular genius, Dr. Erasmus Darwin, whose celebrity was acquired by speculations in poetry and philosophy as well as in medicine, urged Matthew Boulton (subsequently Watt's partner, and just then corresponding with our own Franklin in relation to the use of steam-power), to construct a steam-carriage, or "fiery chariot," as he poetically styled it, and of which he sketched a set of plans.

A young man, named Edgeworth, became interested in the scheme, and in 1768 published a paper which had secured for him a gold medal from the Society of Arts. In this paper he proposed railroads on which the carriages were to be drawn by horses, *or by ropes from steam-winding engines.*

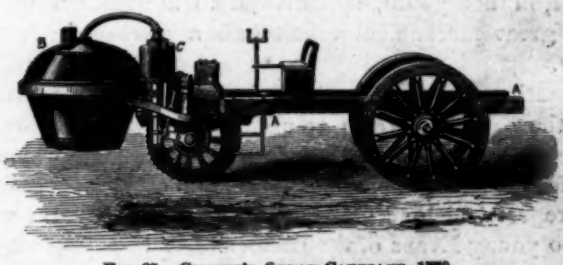

FIG. 25.—CUGNOT'S STEAM-CARRIAGE, 1770.

48. These were merely promising schemes, however. The first actual experiment was made, as is supposed, by a French army officer, Nicolas Joseph Cugnot, who in 1769 built a steam-carriage (Fig. 25), which was set at work in presence of the French Minister of War, the Duke de Choiseul. The funds required by him were furnished by the Comte de Saxe. Encouraged by the partial success of the first locomotive, Cugnot, in 1770, constructed a second which is still preserved in the *Conservatoire des Arts et Métiers*, Paris. This more powerful carriage (Fig. 25) was fitted with two non-condensing single-acting cylinders, thirteen inches in diameter. Although the experiment seems to have been successful, there appears to have been nothing more done with it.

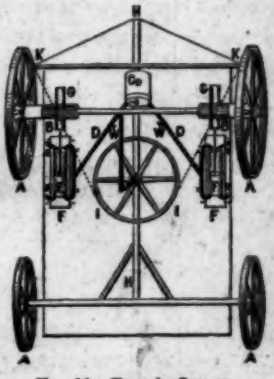

FIG. 26.—READ'S STEAM-CARRIAGE, 1790.

An American of considerable distinction, Nathan Read, patented a steam-carriage, 1790,[1] of the form seen in Fig. 26, which is copied from his patent. The cylinders *F F* lie under the body of the carriage; the pistons *E F* drive racks *B G*, which turn the wheels *A K*. The steering-wheel *I* moves the large wheels *A K*, which lat-

[1] "Nathan Read and his Steam-Engine." New York: Hurd & Houghton, 1870.

ter, turning, carries the engines about with it. It is an ingenious and curious device.

49. "To Oliver Evans," says Dr. Ernest Alban,[1] the learned German engineer, "was it reserved to show the true value of a long-known principle, and to establish thereon a new and more simple method of applying the power of steam—a method that will remain an eternal memorial to its introducers." Dr. Alban here refers to the earliest successful introduction of the non-condensing high-pressure steam-engine.

Oliver Evans, one of the most ingenious mechanics that America has ever produced, was born at Newport, Delaware, in 1755 or 1756, the son of people in very humble circumstances.

He was, in his youth, apprenticed to a wheelwright, and soon exhibited great mechanical talent and a strong desire to acquire knowledge.

His attention was at an early period drawn to this possible application of the power of steam to useful purposes by a boyish prank. Placing a small quantity of water in a gun-barrel, and ramming down a tight wad, he put the barrel in the fire of a blacksmith's forge. The loud report which accompanied the expulsion of the wad was an evidence to young Evans of the great, and, as he supposed, previously undiscovered power of steam.

Subsequently, meeting with a description of a Newcomen engine, he at once noticed that the elastic force of confined steam was not there utilized.

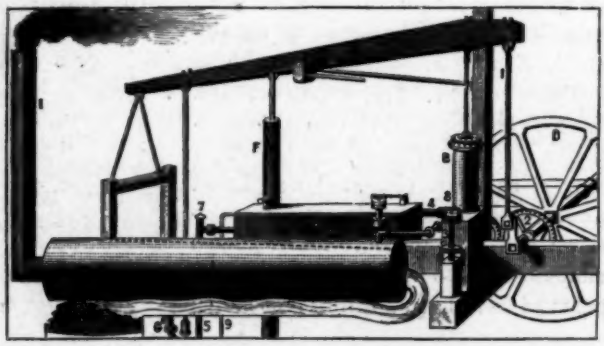

FIG. 27.—OLIVER EVANS'S ENGINE, 1800.

He then designed the non-condensing engine, in which the power was derived exclusively from the tension of high-pressure steam, and proposed its application to the propulsion of carriages.

50. About the year 1780 Evans joined his brothers, who were millers by occupation, and at once employed his inventive talent in

[1] "The High-Pressure Engine investigated," Dr. Ernest Alban, London, 1847.

improving the details of mill-work, and with such success as to reduce the cost of attendance one-half, and also to increase the fineness of the flour made.

In 1785 he applied for, but was refused, a patent for a steam-carriage.

In 1800 or 1801, Evans, after consulting with Prof. Robert Patterson, of the University of Pennsylvania, and getting his approval of the plans, commenced the construction of a steam-carriage, to be driven by a non-condensing engine.

He soon concluded, however, that it would be a better scheme, pecuniarily, to adapt his engine, which was novel in form and of small first cost, to driving mills; and he accordingly changed his plans, and built an engine of six inches diameter of cylinder and eighteen inches stroke of piston, which he applied with perfect success to driving a plaster mill.

51. This engine (Fig. 27), which he called the "Columbian engine," was of a peculiar form.

The beam is supported at one end by a rocking column; at the other it is attached directly to the piston-rod, while the crank lies beneath the beam, the connecting-rod being attached to the latter at about the middle point.

The head of the piston-rod is compelled to rise and fall in a vertical line by the "Evans parallelogram," a kind of parallel motion very similar to one of those designed by Watt.

52. Subsequently, Evans continued to extend the application of his engine and to perfect its details, and, others following in his track, the non-condensing engine is to-day fulfilling the predictions which he made seventy years ago, when he said:

"I have no doubt that my engine will propel boats against the currents of the Mississippi, and wagons on turnpike-roads, with great profit. . . .

"The time will come when people will travel in stages moved by steam-engines, from one city to another, almost as fast as birds can fly—fifteen or twenty miles an hour. A carriage will start from Washington in the morning, the passengers will breakfast at Baltimore, dine at Philadelphia, and sup at New York the same day. . . .

"Engines will drive boats ten or twelve miles an hour, and there will be hundreds of steamers running on the Mississippi, as predicted years ago."

53. In 1804 Oliver Evans completed a flat-bottomed boat (Fig. 28), to be used at the Philadelphia docks, and, mounting it upon wheels, drew it by its own steam-engine to the river-bank. Launching the craft, he propelled it down the river, using its steam-engine to drive its paddle-wheels. Evans's "*oructor amphibolis*," as he named the machine, was the first road-locomotive that we find described after Cugnot's time. Evans asserted that carriages propelled by steam would soon be in common use; and offered a wager of three hundred

dollars that he could build a "steam-wagon" that should excel in speed the swiftest horse that could be matched against it.

Evans's connection with steam-navigation will be referred to when considering that subject.

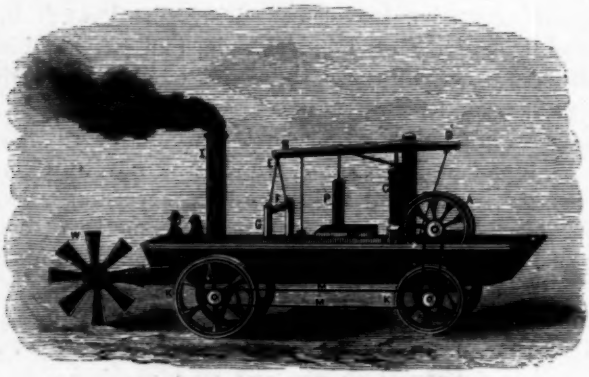

Fig. 28.—"Oructor Amphibolis," 1804.

To this brief sketch of Evans's inventions it can only be added that he devised the flue-boiler, now generally called the Cornish, and used it to furnish steam to his engines.

Richard Trevithick.

54. The earliest non-condensing engine brought into use in Great Britain seems to have been constructed by Richard Trevithick and

Andrew Vivian in 1802. It is stated, by friends of Oliver Evans, that he had, at an earlier date, sent Mr. John Sampson to England, and, by him, had forwarded drawings and specifications, which Trevithick and Vivian inspected, and to which, it is not improbable, they may have been indebted for their plans.

They used a non-condensing, return connecting-rod engine, and carried as high as sixty to eighty pounds of steam.

They built a locomotive-engine in 1804 (Fig. 29), for the railway

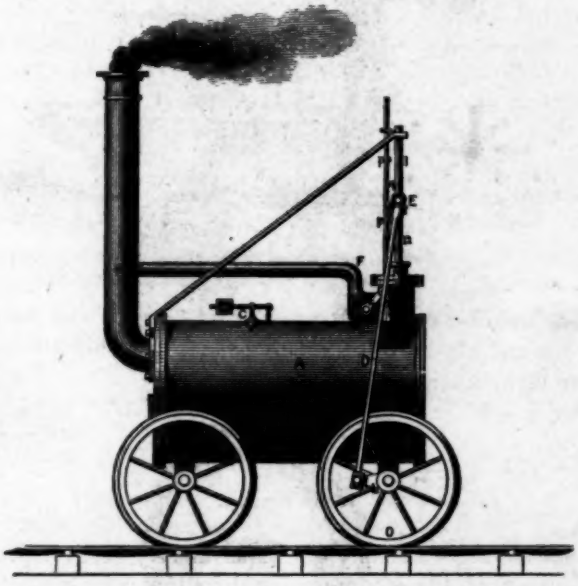

Fig. 29.—Trevithick's Locomotive, 1804.

at Merthyr-Tydvil, in South Wales, which was quite successful, although sometimes giving trouble by slipping its wheels.

This engine had one steam-cylinder $4\frac{1}{2}$ inches diameter, and carried forty pounds steam.

In consequence of a fear of the wheel slipping, Blenkinsop employed, in 1811, a pinion on the locomotive shaft, gearing into a rack on the road-bed.

In 1813 Brunton, of Butterly, tried to introduce a locomotive-engine propelled by levers, like an animal's legs, pushing behind; and just at this time mechanics, all over the world, seem to have become very much interested in this problem.

55. It is at about this period that we find evidence of the intelligent labors of another of our countrymen—one who, in consequence of the unobtrusive manner in which his work was done, has never received the full credit to which he is entitled.

Colonel John Stevens, of Hoboken, as he is generally called, was born in the city of New York, in 1749, but, throughout his business life, he was a resident of New Jersey.

He was undoubtedly the greatest engineer and naval architect living at the beginning of the present century.

JOHN STEVENS.

Without having made any one superlatively great improvement in the mechanism of the steam-engine, like that which gave Watt his fame; without having the honor of being the first to propose navigation by steam, or steam transportation on land, he exhibited a far better knowledge of the science and of the art of engineering than any man of his time, and he entertained and urged more advanced opinions and more statesmanlike views, in relation to the economical importance of the improvement of the steam-engine, both on land and water, than seem to have been attributable to any other leading engineer of that time.

His attention is said to have been first called to the application of steam-power by seeing the experiments of John Fitch with his steamer. He entered upon the work of the introduction of steam in navigation with characteristic energy, and with a success that will be indicated when we come to the consideration of that branch of the subject.

But this far-sighted engineer and statesman saw plainly the importance of applying the steam-engine to land transportation as well as navigation; and not only that, but he saw with equal distinctness

the importance of a well-devised and carefully-prosecuted scheme of internal communication by a complete system of railroads.

56. In 1812 he published a pamphlet embodying "Documents tending to prove the Superior Advantages of Railways and Steam-Carriages over Canal Navigation."[1]

At this time, the only working locomotive in the world was that of Trevithick and Vivian, at Merthyr-Tydvil, and the railroad itself had not grown beyond the old wooden tram-roads of the collieries.

Yet, Colonel Stevens says in this paper, "I can see nothing to hinder a steam-carriage moving on its ways with a velocity of one hundred miles an hour," adding in a foot-note: "This astonishing velocity is considered here merely possible. It is probable that it may not, in practice, be convenient to exceed twenty or thirty miles per hour. Actual experiments can only determine this matter, and I should not be surprised at seeing steam-carriages propelled at the rate of forty or fifty miles an hour."

At a yet earlier date he had addressed a memoir to the proper authorities, urging his plans for railroads.

He proposed rails of timber, protected when necessary by iron plates, or to be made wholly of iron. The car-wheels were to be of cast-iron, with inside flanges to keep them on the track. The steam-engine was to be driven by steam of fifty pounds pressure, and to be non-condensing.

Answering the objections of Robert R. Livingston and of the commissioners of New York, he goes further into details.

57. He gives 500 to 1,000 pounds as the maximum weight to be placed on each wheel, shows that the trains or "suites of carriages," as he calls them, will make their journeys "with as much certainty and celerity in the darkest night as in the light of day," shows that the grades of proposed roads would offer but little resistance, and places the whole subject before the public with such accuracy of statement, and such evident appreciation of its true value, that every one who reads this remarkable document will agree fully with the late President Charles King, of Columbia College, who said that "whosoever shall attentively read this pamphlet will perceive that the political, financial, commercial, and military aspects of this great question were all present to Colonel Stevens's mind, and that he felt that he was fulfilling a patriotic duty when he placed at the disposal of his native country these fruits of his genius.

"The offer was not then accepted. The *Thinker* was ahead of his age, but it is grateful to know that he lived to see his projects carried out—though not by the Government—and that before he finally, in 1838, closed his eyes in death, at the great age of eighty-nine, he could justly feel assured that the name of Stevens, in his own person

[1] Printed by T. & J. Swords, 1160 Pearl Street, New York, 1812.

and that of his sons, was imperishably enrolled among those which a grateful country will cherish."

A patent issued to Colonel Stevens by the British Government in 1805, and a section of a "safety-tubular" boiler subsequently built on the same plan, and used on a locomotive, are preserved in the Stevens Institute of Technology, at Hoboken, New Jersey.

GEORGE STEPHENSON.

58. In 1814 George Stephenson, to whom is generally accorded the honor of having first made the locomotive-engine a success, built his first engine at Killingworth, England.

It had been found during the previous year, by Blackett & Headly, whose engine is still preserved at the South Kensington Patent Museum, that the slipping of the wheels could be avoided without recourse to extraordinary contrivances, and Stephenson made his engine a success, using smooth wheels.

At this time, Stephenson was by no means alone in the field, for the idea of applying the steam-engine to driving carriages on common roads and on railroads was beginning to attract considerable attention.

Stephenson, however, combined in a very fortunate degree the advantages of great natural inventive talent and an excellent mechanical training, his characteristics as an engineer reminding one strongly of those of James Watt. Indeed, Stephenson's portrait bears some resemblance to that of the great inventor.

59. George Stephenson was born in Wylam, in the north of England, near Newcastle-upon-Tyne, and was the son of a "north-country

miner." When still a child, he exhibited great mechanical talent and unusual love of study.

When set at work about the mines, his attention to duty and his intelligence obtained for him rapid promotion, until, when about seventeen years of age, he was made engineer, and took charge of the pumping-engine at which his father was fireman.

A little later he was made engine-wright at Killingworth, where he soon inspired those who employed him with such confidence in his skill and reliability as to obtain an opportunity to design his first locomotive-engine, Lord Ravensworth, one of the principal proprietors, furnishing the necessary funds.

60. In 1815 he applied the blast-pipe in the chimney, by which the puff of the exhaust steam is made useful in intensifying the draught, and applied it successfully to his second locomotive, here seen in section (Fig. 30). This is the essential characteristic of the locomotive-engine.

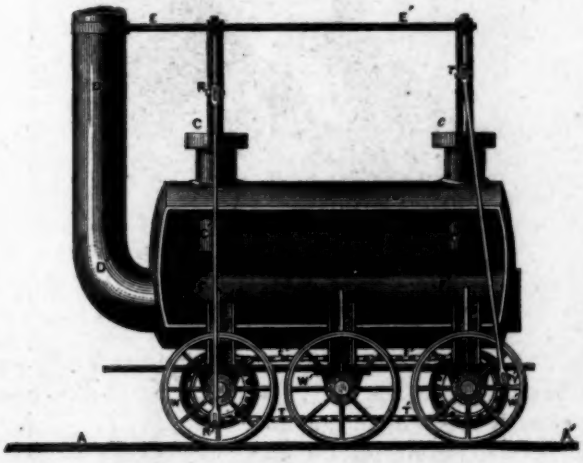

FIG. 30.—STEPHENSON'S LOCOMOTIVE, 1815.

In 1815, therefore, we may say that the modern locomotive steam-engine came into existence, for it is this invention of the blast-pipe that gives it its life, and it is the mechanical adaptation of this and of the other organs of the steam-engine to locomotion that gives George Stephenson his greatest claim to distinction.

61. In 1825 the Stockton & Darlington Railroad was opened, and one of Stephenson's locomotives, in which he employed his "steam-blast," was successfully used, drawing passenger as well as coal trains. Stephenson had at this time become engineer of the road.

The time required to travel the distance of twelve miles was two

hours. This "No. 1 Engine" is still preserved at Darlington Station, mounted on a granite pedestal, as shown in the picture (Fig. 32).

62. One of the most important and interesting occasions in the history of the application of the non-condensing steam-engine to railroads, as well as in the life of Stephenson, was the opening of the Liverpool & Manchester Railroad in the year 1829.

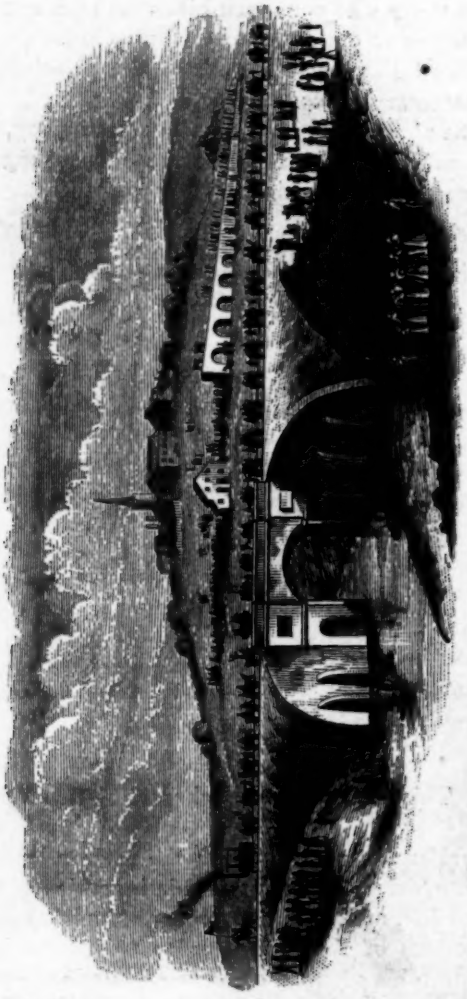

FIG. 31.—OPENING OF THE STOCKTON & DARLINGTON RAILROAD, 1825.

When this road was built, it was determined, after long and earnest discussion, to try whether locomotive-engines might not be used to the exclusion of horses, and a prize of £500 was offered for the best that should be presented at a date which was finally settled at the 6th of October, 1829.

Four engines competed, and the "Rocket," built by Stephenson, received the prize.

63. This engine (Fig. 33) weighed four and one-fourth tons, with its supply of water. Its boiler was of the fire-tubular form, a form

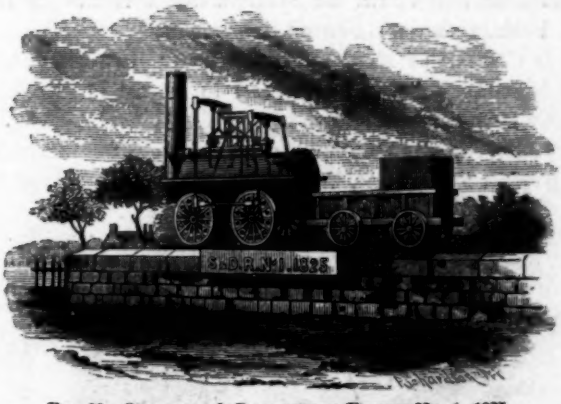

Fig. 32.—Stockton & Darlington Engine No. 1, 1825.

that had grown into shape in the hands of several inventors,[1] and was three feet in diameter, six feet long, with twenty-five three-inch tubes, extending from end to end of the boiler. The steam-blast was carefully adjusted by experiment, to give the best effect. Steam-pressure was carried at fifty pounds per square inch.

The average speed of the Rocket on its trial was fifteen miles per hour, and its maximum was nearly double that, twenty-nine miles an hour; and afterward, running alone, it reached a speed of thirty-five miles.

Fig. 33.—The Rocket, 1829.

The shares of the company immediately rose ten per cent. in value. Thus the combination of the non-condensing engine with a steam-blast and the multitubular boiler, designed by the clear head and constructed under the watchful eye of an accomplished engineer and mechanic, made steam-locomotion so evident and decided a success that thenceforward its progress has been uninterrupted and wonderfully rapid.

[1] Barlow and Fulton, 1795; Nathan Read, Salem, United States, 1796; Booth, of England, and Séguin, of France, about 1827 or 1828.

64. In America the locomotive was set at regular work on railroads, for the first time, on the 8th of August, 1829.[1]

This first locomotive was built by Foster, Rastrick & Co., at Stourbridge, England, and was purchased by Mr. Horatio Allen for the Delaware & Hudson Canal Company's road from Carbondale to Honesdale, Pennsylvania.

Mr. Peter Cooper, of New York, placed an experimental locomotive on the Baltimore & Ohio Railroad in 1829. It ran about fifteen miles an hour at maximum speed.

The first American locomotive to do real service continuously was the "Best Friend" (Fig. 34), built at the West Point Iron Foundery,

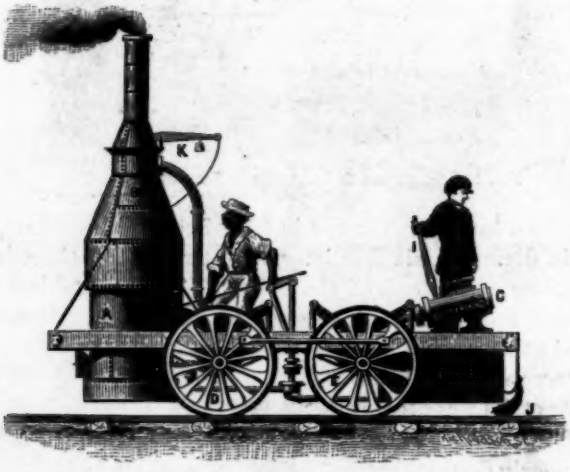

FIG. 34.—THE "BEST FRIEND," 1830.

in the year 1830, for the South Carolina Railroad, on which road it ran from January, 1831, to June 17th of the same year, when it was destroyed by the explosion of its boiler.

A second locomotive (Fig. 35) was built at West Point for the same road in 1831, which resembled somewhat those built at about the same time, and a little later, by Stephenson.

It was at this time (1831), also, that Mr. Horatio Allen introduced the first eight-wheeled locomotives ever built, and gave them a form (Fig. 36) which will be at once recognized by the engineer as the prototype of a recently-built locomotive which has been brought out in Great Britain. In this year, also, an engine, the De Witt Clinton, was built for John B. Jervis of the Mohawk & Hudson Railroad.

65. At about the time of the opening of the early railroads, the

[1] "History of the First Locomotive in America," W. H. Brown. D. Appleton & Co., New York, 1872.

introduction of steam-carriages on the common highway had become a favorite idea with engineers.[1]

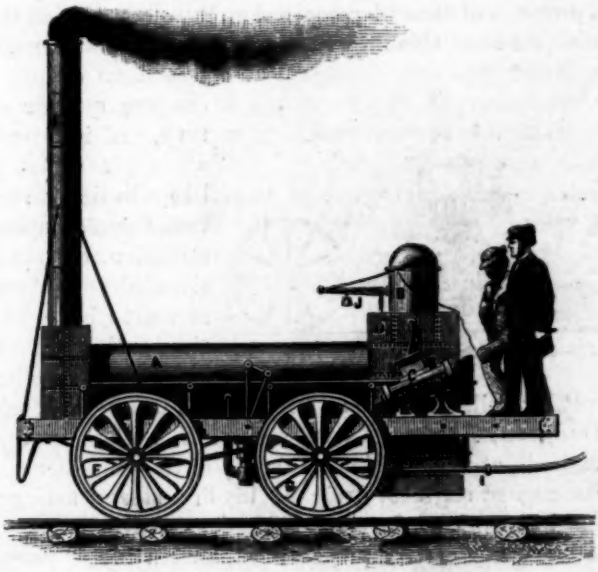

Fig. 35.—The West Point, 1831.

In December, 1833, about twenty steam-carriages and traction road-engines were running or were in course of construction in and near London.

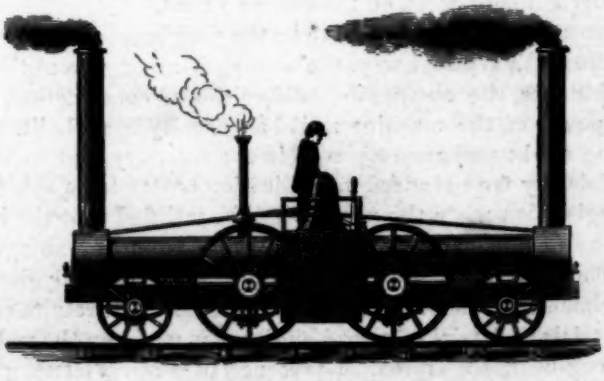

Fig. 36.—The South Carolina, 1831.

In our own country, the roughness of roads discouraged inventors, and, in Great Britain even, the successful introduction of road-locomotives, which seemed at one time almost an accomplished fact, finally

[1] "Road-Locomotives and Traction-Engines," *Journal of the Franklin Institute*, 1871.

met with so many obstacles that even Hancock and Gurney, the most ingenious, persistent, and successful constructors, gave up in despair. Hostile legislation procured by opposing interests, and possibly also the rapid progress of steam-locomotion on railroads, caused this result.

In consequence of this interruption of experiment, almost nothing was done during the succeeding quarter of a century, and it is only within a few years that anything like a business success has been founded upon the construction of road-locomotives, although the scheme seems to have been at no time entirely given up.

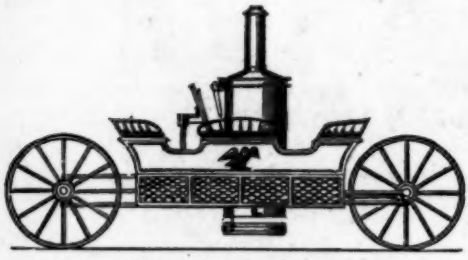

FIG. 37.—FISHER'S STEAM-CARRIAGE, 1870.

Messrs. Aveling & Porter, J. Scott Russell, Boydell, and a few others in England, and Messrs. Roper, Dudgeon, Fawkes, Latta, and J. K. Fisher, in the United States, have all, at various times, labored in this direction.

The last-named engineer designed his first steam-carriage in 1840, and was still at work at the time of his death, in 1873.

Abroad, a few firms have succeeded, within a few years past, in making a business of considerable extent in constructing road-locomotives for hauling heavy loads, and in building steam road-rollers.

While steam-carriages of high speed, and adapted to the transportation of passengers, have not yet been successfully introduced, a most promising start has been made in the application of steam to the heavier kinds of work on the common road.

The great impediments seem to be the roughness and bad construction of the ordinary highway, the damages arising from the taking fright of horses, the engineering difficulties of construction, and the limited power of the machine as it has usually been built. Hostile legislation might perhaps be placed in the category, but we are probably sufficiently far advanced in civilization to-day to be able to secure liberal legislation when the people shall be satisfied that the introduction of the road-locomotive will be of great public advantage.

66. The capabilities of the road-locomotive are readily determined by experiment, and the following is an abstract of the results of several series of trials.[1] A trial of a road-engine was made by the well-known French engineer, H. Tresca, in presence of Prof. Fleeming Jenkin, and the report was submitted on January 15, 1868. The results were as follows: 1. The coefficient of traction was about 0.25 on a good road with easy grades. 2. The consumption of coal was 4.4 pounds per horse-power per hour. 3. The consumption of water was 132.2 gallons an hour with the ten-horse engine. 4. The coefficient of ad-

[1] Appletons' American Cyclopædia, article "Steam-Carriage."

herence, or of friction between the wheels and the soil, was 0.3. 5. A speed of seven miles an hour caused no special difficulty in managing either the locomotive or its load. At about this time M. Servel con-

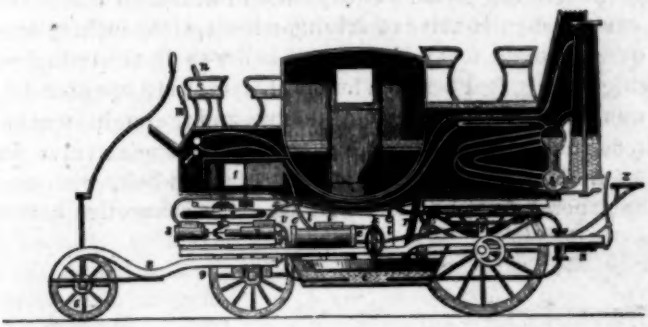

FIG. 38.—GURNEY'S STEAM-CARRIAGE, 1833.

ducted a series of experiments with a similar machine upon paved and upon macadamized roads, during what he described as the most trying of winter weather. He reports the following distribution of weight per cent.:

| | |
|---|---|
| Weight of locomotive | 41.4 |
| " " wagons | 18.2 |
| " " paying load | 40.4 |
| Total | 100 |

The average total weight of three loaded wagons, which was the usual load, was 22,575 kilogrammes, or about twenty-two tons. The experiment was made in 1867–'68 of applying these engines to the towage of boats on the French canals, with very encouraging results.

In 1871 several traction-engines were exhibited before the Royal Agricultural Society of England at Wolverhampton, and the judges made a series of careful tests, reported in its "Journal" for that year. The coal used on special trial amounted to 3.2 pounds per indicated horse-power per hour, and the evaporation of water was 7.62 pounds per pound of coal consumed, the average temperature of feed being 175° Fahr. The load drawn up the maximum grade of 264 feet to the mile on Tottenham Hill, which is 1,900 feet from top to bottom, was twenty-six tons, and including weight of engine thirty-eight tons, giving a coefficient of traction of 0.35. On a country-road sixteen miles long it drew fifteen tons at an average rate of 3¼ miles an hour, using 2.85 pounds of coal and 1.94 gallon of water per ton of useful load per mile.

67. In October, 1871, the writer conducted a public trial of road-engines and steam road-rollers, on a well-macadamized road at South Orange, New Jersey. Two road-steamers (Fig. 39) or traction-en-

gines and a steam road-roller were tried. The following were the principal dimensions: Weight of engine complete, five tons four hundred-weight (11,648 pounds); diameter of steam-cylinder, $7\frac{3}{4}$ inches; stroke of piston, ten inches; revolutions of crank to one of driving-wheel, seventeen; diameter of driving-wheels, sixty inches; length of boiler over all, eight feet; diameter of boiler-shell, thirty inches; load on driving-wheels, four tons ten hundred-weight (10,080 pounds). The boiler was of the ordinary locomotive type, and the engine was mounted upon it, as is usual with portable engines. The engine valve-gear consisted of a three-ported valve and Stephenson-link, with reversing lever, as generally used on locomotives. The connection between the

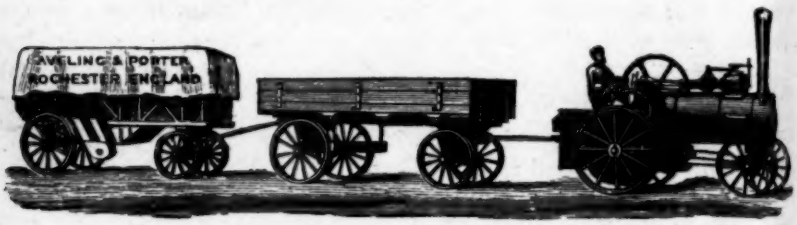


FIG. 39.—MODERN ROAD-LOCOMOTIVE.

gearing and the driving-wheels was effected by the device called by builders of cotton-machinery a Jack-in-the-box gear, or differential gear. By this combination, the effort exerted by the engine is made equal at both wheels at all times, even when the engine is turning a corner. The following is a summary of the conclusions deduced from the trial, and published in the *Journal of the Franklin Institute:* A traction-engine may be so constructed as to be easily and rapidly manœuvred on the common road; and an engine weighing over five tons may be turned continuously without difficulty on a circle of eighteen feet radius, or even on a road but little wider than the length of the engine. A locomotive of five tons four hundred-weight has been constructed, capable of drawing on a good road 23,000 pounds up a grade of 533 feet to the mile, at the rate of four miles an hour; and one might be constructed to draw more than 63,000 pounds up a grade of 225 feet to the mile, at the rate of two miles an hour. It was further shown that the coefficient of traction with heavily-laden wagons on a good macadamized road is not far from $\frac{1}{100}$; the traction-power of this engine is equal to that of twenty horses; the weight, exclusive of the weight of the engine, that could be drawn on a level road, was 163,452 pounds; and the amount of fuel required is estimated at 500 pounds a day. The advantages claimed for the traction-engine over horse-power are: No necessity for a limitation of working-hours; a difference in first cost in favor of steam; and in heavy work on a common road the expense by steam is less than twenty-five per

cent. of the average cost of horse-power, a traction-engine capable of doing the work of twenty-five horses being worked at as little expense as six or eight horses.

68. Now, thirty years after the defeat of the intelligent, courageous and persistent Hancock and his co-workers in the scheme of applying the steam-engine usefully on the common road, we find strong indications that, in a new form, the problem has been again attacked and at least partially solved. It was formerly supposed that success in the transportation of passengers by steam on post-routes would lead to the application of that motor to the movement of heavy loads and to agricultural purposes generally. When, after so long a trial, the experiment finally seemed to have failed of success, it was believed that steam could not be applied to heavier work on common roads. As we have now seen, however, it appears probable that the inventors of that day attacked the problem at the wrong point, and that, on the common road, the transportation of heavy loads by steam being accomplished with economical success, under ordinarily favorable circumstances, it may prove introductory to the use of steam in carrying passengers and light freight at higher velocities.

One of the most important of the prerequisites to ultimate success in the substitution of steam for animal power on the highway is that our roads shall be well made.

As the greatest care and judgment are exercised, and an immense outlay of capital is considered justifiable, in securing easy grades and a smooth track on our railroad routes, we may readily believe that similar precaution and outlay will be found advisable in adopting the common road to the road-locomotive.

It is undeniably the fact that, even when relying upon horse-power, far less attention has been paid to the improvement of our roads than true economy would dictate. With steam-power, the gain by careful grading and excellence of construction of the road-bed becomes still more important. The animal mechanism is less affected in its power of drawing heavy loads than is the machine. With the horse, a bad road impedes transportation principally by resisting the movement of the load rather than of the animal, while with the traction-engine the motor is as seriously retarded as the train which follows it, and frequently much more, on soft ground.

Steam, therefore, cannot be expected to attain its full measure of success on rough and ill-made roads; but where highways are intelligently engineered and thoroughly well built, or where Nature has relieved the engineer and the road-builder of the expensive work of grading, as throughout a very large extent of the Western and Southern portion of our country, we may expect to see the road-locomotive rapidly introduced.

The earliest and most perfect success of the traction-engine, and its probable successor, the steam-carriage, may be expected to occur

in such districts. Its great economical advantage over animal power, its freedom from liability to become disabled by epizoötic diseases, its reliability under all circumstances, and the many other advantages which are possessed by the machine, are already securing its introduction, despite the difficulties arising from popular prejudice and unfamiliarity, from hostile municipal laws and other existing obstacles.

We are learning that this motor, when it can be used at all, is comparatively inexpensive; that our roads are improved by it; and that the ancient idea of its conflicting with the interests of owners and workers of horses is only a superstition.

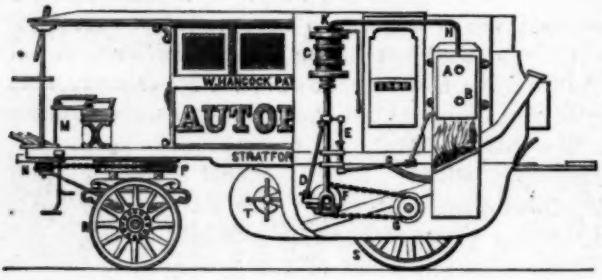


FIG. 40.—HANCOCK'S STEAM-CARRIAGE, 1833.

Such a commencement having been made, it is difficult to conceive how great may not be the future of this branch of industry when the valley of the Mississippi and our Western plains, the natural habitat of this motor, shall have become finally a principal seat of its manufacture as well as of its employment.[1]

69. The steam-blast of Hackworth, the tubular boiler of Séguin, and the link-motion of Stephenson, constitute the essential features of the modern locomotive. Locomotives have gradually and steadily increased in size and power from the date of their introduction. The Rocket, which first proved conclusively, in 1829, the value of steam-locomotion, weighed 4¼ tons. In 1835 Robert Stephenson, who had constructed it with his father, writing to Robert L. Stevens, said that he was making his engines heavier and heavier, and that the engine of which he inclosed a sketch weighed nine tons, and could draw "100 tons at the rate of sixteen miles an hour, on a level." Locomotives are now built weighing seventy tons, and powerful enough to draw more than 2,000 tons at a speed of twenty miles an hour. The modern locomotive consists of a boiler, mounted upon a strong light frame of forged iron, by which it is connected with the wheels. The largest engine yet constructed in the United States is said to be one in use on the Philadelphia & Reading Railroad, having a weight of about 100,000 pounds, which is carried on twelve driving-wheels. A locomotive has two steam cylinders, either side

[1] *Vide* paper by the author, *Journal of the Franklin Institute*, 1871.

by side within the frame, and immediately beneath the forward end of the boiler, or on each side and exterior to the frame. The engines are non-condensing and of the simplest possible construction. The whole machine is carried upon strong but flexible steel springs. The steam-pressure is usually more than 100 pounds. The pulling-power is generally about one-fifth the weight under most favorable conditions, and becomes as low as one-tenth on wet rails. The fuel employed is wood in new countries, coke in bituminous coal districts, and anthracite coal in the eastern part of the United States.

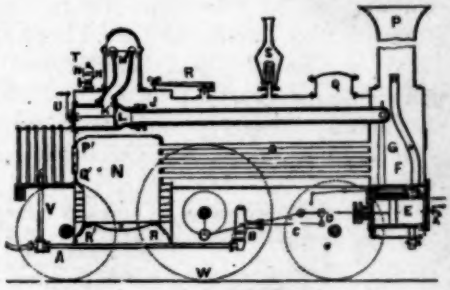


FIG. 41.—BRITISH EXPRESS-ENGINE.

The general arrangement and the proportions of locomotives differ somewhat in different localities. In Fig. 41, a British express-engine, *O* is the boiler, *N* the fire-box, *X* the grate, *G* the smoke-box, and *P* the chimney. *S* is a spring, and *R* a lever safety-valve, *T* is the whistle, *L* the throttle or regulator valve, *E* the steam-cylinder, and *W* the driving-wheel. The force-pump, *B C*, is driven from the cross-head, *D*. The frame is the base of the whole system, and all other parts are firmly secured to it. The boiler is made fast at one end, and provision is made for its expansion when heated. Adhesion is secured by throwing a proper proportion of the weight upon the driving-wheel *W*. This is from about 6,000 pounds on standard freight-engines, having several pairs of drivers, to 10,000 pounds on passenger-engines, per axle. The peculiarities of the American type (Figs. 42, 43) are the truck or bogie supporting the forward part of the engine, the system of equalizers, or beams which distribute the weight of the machine equally over the several axles, and minor differences of detail. The cab or house protecting the engine-driver and fireman is an American device, which is gradually coming into use abroad also. The American locomotive (Fig. 43) is distinguished by its flexibility and ease of action even upon roughly-laid roads. The cost of passenger-locomotives of ordinary size is about $12,000; heavier engines sometimes cost $20,000. The locomotive is usually furnished with a tender, which carries its fuel and water. The standard passenger-engine on the Pennsylvania Railroad is quite similar in form to the Baldwin engine (Fig. 42), and has four driving-wheels (*G*, *H*), 5½ feet diameter; steam-cylinders (*C*, *D*), seventeen inches diameter and two feet stroke; grate-surface (*N*) 15½ square feet, and heating-surface 1,058 square feet. It weighs 63,100 pounds, of which 39,000 pounds are on the drivers and 24,100 on the truck, *L K*. The shell of the boiler is 49¼ inches diameter and 20 feet 2½ inches long.

The fire-box, *N N*, is of steel, six feet two inches long outside, 3½ feet wide, and five feet four inches high. The tubes, *O O*, are of iron, 142 in number, 2¼ inches diameter, and eleven feet seven inches long. The steam-dome, *R*, is thirty inches outside diameter, the smoke-

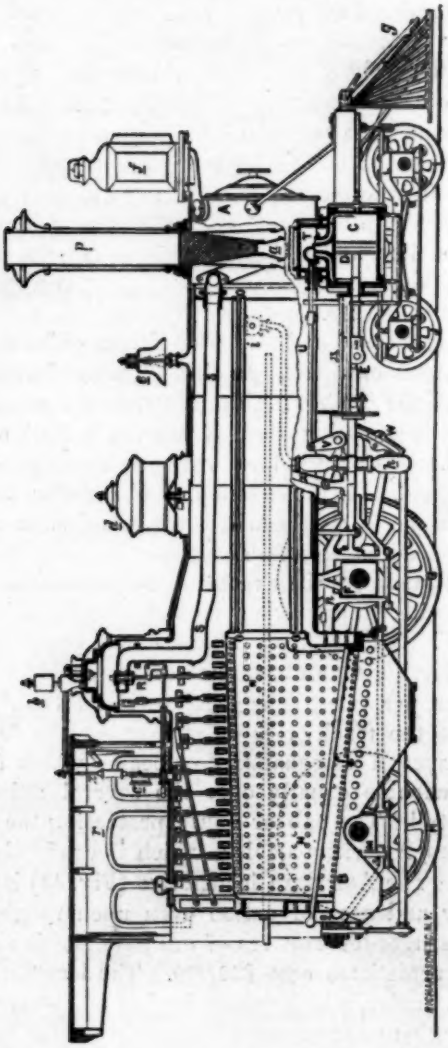

FIG. 42.—THE BALDWIN LOCOMOTIVE, 1878.

stack, *p*, 14½ inches. The feed-water is supplied by one pump, *h*, of 2½ inches diameter and two feet stroke, and by a No. 8 Giffard injector. The valves, *T*, are 16½ inches wide by 8½ inches long, and have five inches travel. The steam-ports are 15$\frac{15}{16}$ inches wide and 1¼ inch long, and the exhaust-port 15$\frac{15}{16}$ by 2½ inches. The lap of the

valve is, outside $\frac{3}{4}$ inch, inside $\frac{1}{64}$ inch. The eccentrics have a throw of $4\frac{1}{2}$ inches. The standard freight-engine has six driving-wheels, $54\frac{1}{2}$ inches in diameter. The steam-cylinders are eighteen inches in diameter, stroke twenty-two inches, grate-surface 14.8 square feet, heating-surface 1,096 feet. It weighs 68,500 pounds, of which 48,000 are on the drivers and 20,500 on the truck. The boiler is nearly of the same dimensions as that of the passenger-engine, but the tubes are $2\frac{1}{2}$ inches in diameter, twelve feet $9\frac{5}{16}$ inches long, and 119 in number. The stack is eighteen inches in diameter. The pump is $2\frac{1}{4}$ inches in diameter, and has a stroke of twenty-two inches. The valve has $\frac{3}{4}$ inch inside lap, $\frac{1}{16}$ inch outside. The former takes a train of five cars up an average grade of ninety feet to the mile. The latter is attached to a train of eleven cars. On a grade of fifty feet to the mile, the former takes seven and the latter seventeen cars. Tank-engines for very heavy work, such as on grades of 320 feet to the mile, which are found on some of the railroads where gradients are very steep, have five pairs of coupled driving-wheels, and are not fitted with trucks. Such engines have, usually, steam-cylinders about twenty inches in diameter and two feet stroke of piston. Their grates have an area of fifteen or sixteen square feet, and the heating-surface has an area of 1,400 to 1,500 square feet. Engines of this class, weighing fifty tons, have hauled 110 tons up the heaviest grades of the Pennsylvania Railroad at the rate of five miles an hour. Steam-pressure is carried at from 125 to 150 pounds on the square inch.

70. A train weighing 150 tons is drawn by an express-engine (Fig.

FIG. 43.—STANDARD PASSENGER AND EXPRESS ENGINE, 1878.

43) at the speed of sixty miles an hour, the engine developing about 800 horse-power.[1] An engine drawing a light train has been known to make about one hundred miles in one hundred minutes, which speed may be taken as representing the maximum for the best modern engines on the best existing roads.

[1] Nearly equivalent to the actual power of 1,200 horses.

The life of the locomotive, when well cared for, cannot be exactly stated, but may be taken as not far from thirty years. Repairs cost, annually, ten or fifteen per cent. of the first cost. While running, each engine requires about four pints of oil and two tons of coal for each one hundred miles.

71. After their introduction, the growth of railroads and the use of locomotives extended in the United States and in Europe with great rapidity.

The first railroad in the United States was built near Quincy, Massachusetts, in 1826.

In 1850 there were about 700 miles in operation; in 1860 there were over 30,000; and there are to-day about 76,000 miles of completed road in the United States, and the rate of increase had risen in 1873 to above 7,000 miles per year, as a maximum, and the consumption of rails for renewal alone amounts to nearly a half-million tons per year.

## HEALTH-MATTERS IN JAPAN.

By EDWARD S. MORSE.

THE problem which excites more interest than any other in the larger cities of our country is that in regard to the best disposition of sewage. People have slowly come to realize that in some way a series of disorders arises from the presence of waste matter in cities. So well ascertained is this fact that diseases which are attributed to the presence of filth are aptly called *filth-diseases*, and it is well that they are at last branded by their right name. One has only to consult the valuable reports of the State boards of health for infomation on these matters. In these reports he will find an overwhelming mass of evidence tracing typhoid fever, cholera infantum, and other diseases, to the presence of filth, and to its

infectious character when communicating with water-supplies, or through its malarial gases affecting the air of houses. At present the causes of high death-rates are as certainly known as the course of storms. Indeed, the intelligent physician will predict the necessary consequences which must ensue from the presence in a crowded city of matter which should be removed. Interested as I have been in these subjects, I looked forward with considerable eagerness to an opportunity for studying the conditions which obtain among the Japanese concerning these matters. Their manner of living, their food, their domestic habits, are all so different from ours, that it naturally occurred to me, if these filth-diseases are as common here, with their cleanly habits, and the universal custom of removing offal from their dwellings, as with us where the same matter lies in a frightful state for months to pollute the neighborhood, then the points urged in regard to the relations between filth-diseases and offal must be modified or abandoned.

What do the facts show?

At home, the following conditions are rightly looked upon as grave sources of danger: the presence of privies in the vicinity of wells, cellars filled with decaying vegetable matter, a water-closet or privy connected immediately with a house, or the ingress of sewage-gas to a house. It is at present difficult to get any vital statistics regarding the Japanese. While the Government and people have made the most surprising strides toward the civilization of Western nations (for they have a civilization of their own which in many respects is far ahead of ours[1]), and have established normal schools and universities, medical and naval colleges, hydrographic and other surveys, they have not yet seen the importance of organizing a board of health.[2]

One would be justified in assuming that if these sources of danger existed, the foreigner, unacclimated as he is, would be more susceptible to their influence than the native. Dr. Stuart Eldridge, of Yokohama, a distinguished physician, who has had a long and varied experience in this country in hospital-work and as an active practitioner, has kindly furnished me with the following data at my request: "Scarlet fever *almost unknown*, never epidemic. Diphtheria almost unknown, never epidemic. Severer forms of bowel-disease, such as dysentery and chronic diarrhœa, very rare. Mala-

[1] If some of the indications of civilization are to treat each other kindly, to treat their children with unvarying kindness, to treat the animals below them with tenderness, to honor their father and mother, to be scrupulously clean in their persons, to be frugal and temperate in their habits—if these features be recognized as civilized, then this pagan nation in these respects is as far ahead of us as we are ahead of the Tierra del Fuegans.

[2] We ought not to expect this of Japan, perhaps, since the representatives sent by Maine to her Legislature were, with few exceptions, too ignorant to appreciate the necessity of a State board of health, and were incredulous that the physicians who urged the measure so strongly were unselfishly working for its establishment!

rial diseases of severe nature uncommon; even the milder forms in most localities not common. Typhoid and typhus rarely epidemic, the latter uncommon." With these facts before us, let us examine the conditions of living among these people. It is well known that their houses are so arranged that the winds blow through them from one end to the other. In summer they are entirely open. The privies are never connected immediately with the houses except among the lower classes in the larger cities, where, as in Tokio for example, among the poorer houses the privy is in the back part of the house, but even in these cases a close sliding-door always separates this apartment from the living-room, and a grated window without glass permits thorough ventilation. In the public inns, too, the privy is sometimes connected with the building, to the great discomfort of foreigners. In the country villages it stands alongside the road, separate from the house. Their sewage system, so far as I am aware, is superficial, and there is no sewage-gas to contaminate the air. The houses have no cellars, and consequently the air in them is not polluted from this source. On the other hand, their wells are not always properly situated, and the water is liable to pollution from gutters. The important point to be noted, however, is in regard to the disposition of their offal, and it is well known that every day or two this is removed and scattered on their rice-fields and other cultivated areas. The vaults consist of water-tight vessels of limited capacity. In Tokio they use for this purpose oil-barrels, which they coat with a kind of varnish inside and out. From the small size of this vessel accumulation never occurs, and from its nature the soil never becomes saturated by its contents. Men, instead of being paid to remove it, actually pay for it!

The Japanese having no cattle or sheep, but few horses, no pigs, and but few fowls at the most, depend entirely upon the sewage of towns for the fertilizing material of their farms. No one at home can form any idea of the perfect manner of this work. Even in as large a city as Tokio, with its million inhabitants, this service is performed with a neatness and thoroughness which surpasses belief. The foreigner finds one of his senses rudely assailed at times, though, as to that matter, he may go into one of the most refined cities of America, and, with the exception of a few summer months, encounter the same discomforts. Dr. David Murray has called my attention to the very important service performed by the crows and a kind of hawk which act as scavengers. We are so accustomed at home to find these birds especially wild and wary, that it is a somewhat startling sight to see them perching on the buildings in a crowded city like Tokio, and swooping down in front of you in quest of food, which might otherwise decay and vitiate the atmosphere. The destructiveness and brutality, generally speaking, of the children of Christian nations lead to the stoning of dogs, cats, and birds of all

kinds. In Japan such a thing is unknown, and a stone thrown at a dog (I speak from experience) is generally answered by an inquiring look, hens hop out of the way, and even cats do not take the hint! In other words, the crows and hawks are never molested, and the result is that all carrion and other stuff left in the streets are pounced upon and carried off immediately.

As far as climatic conditions are concerned everything is most favorable for the development of filth-diseases, provided the sources of danger were present. In the summer months the heat is oftentimes oppressive, the moisture excessive, meat decays rapidly, and the decomposition of fruit and vegetables quickly ensues. With fruit especially ripeness is almost coincident with decay.

In regard to the personal habits of the people, it is interesting to remark that they drink very little cold water. The water is drunk as hot tea—in other words, it is boiled. Of extreme importance, too, in regard to children's disorders, is the fact that, until they are two or three years old, they draw their nourishment from the maternal fount. *No child is fed artificially.*

On the other hand, it is interesting to note that the Japanese eat unripe fruit to an inordinate extent. The moment fruit shows the slightest signs of being soft as an evidence of ripeness, it is considered by them as unfit to eat. It is astonishing to see them eat hard, green peaches—clinching them in the fist, as a country boy does a hard apple, and biting off each mouthful with a loud snap. They eat their pears in the same way; cucumbers are eaten in a more unripe condition than with us even; and water-melons, which are so much inveighed against at home, are here eaten by all classes and at all times.

In fact, they seem to revel in those things which at home are considered so productive of summer-complaints; who does not recall the astonishment he has felt at the sight of country children of tender age eating green apples, green corn uncooked, and similar things, and yet suffering no ill-effects therefrom? These facts may not prove, perhaps, that unripe fruit is harmless; but, in connection with the other statements, they do show that the removal of sewage-matter from houses is the important point to consider, and that its removal insures an absence, or a less number, of cases of those diseases which enhance our death-rate at home, and lends an additional reason for the necessity of vigilance on the part of communities regarding these matters.

Concerning sunstroke, it is believed at home that one of its inciting causes is the exposure of the body or head to the overpowering heat of the sun; and the subjection of the uncovered head to the direct rays of the sun is looked upon as dangerous. On the other hand, it is admitted that intemperance in food or drink, and particularly the latter, may be inducing causes. Be that as it may, it is sug-

gestive to note the rare occurrence of sunstroke among the Japanese, and to remark that two out of three go bareheaded. The women never have their heads covered, and the men do not always protect theirs with the sun-shade. Among the lower classes, few have their heads covered except in the hottest weather—the Jinrikisha men and the Bettoes[1] running for miles bareheaded. In most cases the head is shaved on top. If exposure of the head to the direct rays of the sun is the inducing cause of sunstroke, then here, in latitude 35°, we should expect numerous cases, while, if over-eating and over-drinking—in other words, intemperate habits—are the inducing causes, then we can understand the immunity of the Japanese from this malady: for a more temperate and frugal people do not exist on the face of the globe.

One observes in traveling through the country the almost entire absence of deformities arising from accidents—no broken backs or broken noses, no unequal legs, or other mutilations or deformities of any sort. A fruitful source of these misfortunes at home may be traced to accidents which befall children, such as falling out of windows, tumbling down-stairs, being knocked down in the street by runaway horses, and, in later years, the deformities of the face, oftentimes the result of drunken rows and fights; the common occurrence of building-accidents, from insecure and dishonest staging, and the hundreds of other ways in which mutilations are met with in large factories. In Japan the houses are one story high; generally speaking, there are no windows to tumble out of, or flights of stairs to tumble down. Horses, except as pack-horses, are rare.[2] The people do not have drunken brawls. Their stagings are always built to hold together, and thus pagan temples are reared, and pagan temples are repainted, without those appalling accidents which occur in a service of like nature at home. There are no big factories; and so, with these sources of danger eliminated, we find a reason, perhaps, for the absence of deformities.

In regard to the prevalence of certain other diseases which may be of interest in a paper of this nature, it is gratifying to know that small-pox, which was formerly endemic, is now coming under control by the Government taking active measures to insure vaccination. A vaccine farm is maintained, and it is compulsory on every one to be vaccinated. The frightful scourges of this disease in past times are seen in the sadly-scarred faces of so many of the people, and in the number of blind persons one encounters.

Eye-diseases of various kinds are prevalent, and near-sightedness seems very common, judging from the number of people who wear glasses. Weakness of vision must in some measure be attributed to

[1] Bettoes are servants who run beside the horses or before them when one is driving.

[2] Only within a few years have horses been used in the streets of Tokio, and a police regulation requires a man to run in front of each one in every crowded thoroughfare.

the poor light the people provide themselves with. A dim candle, or, at most, a tiny wick resting on the edge of a vessel of vegetable oil of feeble illuminating power, and this inclosed in a paper lantern, is the almost universal lamp of the Japanese; and with this dim light the student studies his Chinese classics, the characters of which are so confusedly wrought together, and the woman performs her sewing on the customary dark-blue cloth. The gradual introduction of kerosene-oil, which is now going on, must in some way modify these troubles.

Measles is occasionally epidemic, and, owing to the exposed life of the people, often very severe. Phthisis is not more common in Japan than in our Middle States. Articular rheumatism is not common, but muscular rheumatism is very common. Skin-diseases are common, especially the contagious forms. The universal use of the razor in shaving, and the custom of itinerant barbers, who travel from one village to another shaving indiscriminately, indicate too plainly the reason for the prevalence of contagious diseases of the skin. In Japan everybody shaves. The men shave the tops of their heads, the beard and mustache, and, curiously enough, every portion of the face, even to the eyelids (not the eyelashes), the lobes of the ears, and the nose to its very tip. Married women shave their eyebrows; widows and priests shave the entire scalp; babies even have their heads shaved in such a manner as to leave the most grotesque bunches of hair symmetrically disposed, like a fancy garden-plot, the remaining portions of the scalp being entirely denuded. It is rather the exception than the rule to find a child's head free from an eruption of some kind, and for this reason, as a general thing, the Japanese babies are unattractive.

My observations on the facts kindly furnished me by Dr. Eldridge apply only to the region about Tokio. The experience upon which these are made is based on a tour of a hundred miles to the northwest of Tokio, a good part of the inland journey being made on foot, many rambles through the streets of Tokio, and a six weeks' sojourn in a little village seventeen miles south of Yokohama. During all these trips and sojourns I have had my note and sketch book constantly with me, and have given the strictest attention to the sanitary condition of the houses and their surroundings.

In conclusion, it is gratifying to know that more solid progress has been made in medicine and surgery than in any other branch of Western science, and that the old Chinese system, with its grotesque absurdities, is doomed.

P. S.—Just as I am mailing this, the alarming news comes that the Asiatic cholera has made its appearance in Yokohama in the most emphatic manner. It will, of course, extend to Tokio; and, curiously enough, the very customs of the people which tend to thwart the rav-

ages of certain other diseases will in this case be the very conditions to promote the ravages of cholera. A parallel case would be that of carefully removing the coals of fire from a building every night, as a safeguard to the structure; but let a sudden gale spring up, and the embers thus removed would be scattered far and wide.

## ILLUSTRATIONS OF THE LOGIC OF SCIENCE.

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### SECOND PAPER.—HOW TO MAKE OUR IDEAS CLEAR.

#### I.

WHOEVER has looked into a modern treatise on logic of the common sort, will doubtless remember the two distinctions between *clear* and *obscure* conceptions, and between *distinct* and *confused* conceptions. They have lain in the books now for nigh two centuries, unimproved and unmodified, and are generally reckoned by logicians as among the gems of their doctrine.

A clear idea is defined as one which is so apprehended that it will be recognized wherever it is met with, and so that no other will be mistaken for it. If it fails of this clearness, it is said to be obscure.

This is rather a neat bit of philosophical terminology; yet, since it is clearness that they were defining, I wish the logicians had made their definition a little more plain. Never to fail to recognize an idea, and under no circumstances to mistake another for it, let it come in how recondite a form it may, would indeed imply such prodigious force and clearness of intellect as is seldom met with in this world. On the other hand, merely to have such an acquaintance with the idea as to have become familiar with it, and to have lost all hesitancy in recognizing it in ordinary cases, hardly seems to deserve the name of clearness of apprehension, since after all it only amounts to a subjective feeling of mastery which may be entirely mistaken. I take it, however, that when the logicians speak of "clearness," they mean nothing more than such a familiarity with an idea, since they regard the quality as but a small merit, which needs to be supplemented by another, which they call *distinctness*.

A distinct idea is defined as one which contains nothing which is not clear. This is technical language; by the *contents* of an idea logicians understand whatever is contained in its definition. So that an idea is *distinctly* apprehended, according to them, when we can give a precise definition of it, in abstract terms. Here the professional logicians leave the subject; and I would not have troubled the

reader with what they have to say, if it were not such a striking example of how they have been slumbering through ages of intellectual activity, listlessly disregarding the enginery of modern thought, and never dreaming of applying its lessons to the improvement of logic. It is easy to show that the doctrine that familiar use and abstract distinctness make the perfection of apprehension has its only true place in philosophies which have long been extinct; and it is now time to formulate the method of attaining to a more perfect clearness of thought, such as we see and admire in the thinkers of our own time.

When Descartes set about the reconstruction of philosophy, his first step was to (theoretically) permit skepticism and to discard the practice of the schoolmen of looking to authority as the ultimate source of truth. That done, he sought a more natural fountain of true principles, and professed to find it in the human mind; thus passing, in the directest way, from the method of authority to that of apriority, as described in my first paper. Self-consciousness was to furnish us with our fundamental truths, and to decide what was agreeable to reason. But since, evidently, not all ideas are true, he was led to note, as the first condition of infallibility, that they must be clear. The distinction between an idea *seeming* clear and really being so, never occurred to him. Trusting to introspection, as he did, even for a knowledge of external things, why should he question its testimony in respect to the contents of our own minds? But then, I suppose, seeing men, who seemed to be quite clear and positive, holding opposite opinions upon fundamental principles, he was further led to say that clearness of ideas is not sufficient, but that they need also to be distinct, i. e., to have nothing unclear about them. What he probably meant by this (for he did not explain himself with precision) was, that they must sustain the test of dialectical examination; that they must not only seem clear at the outset, but that discussion must never be able to bring to light points of obscurity connected with them.

Such was the distinction of Descartes, and one sees that it was precisely on the level of his philosophy. It was somewhat developed by Leibnitz. This great and singular genius was as remarkable for what he failed to see as for what he saw. That a piece of mechanism could not do work perpetually without being fed with power in some form, was a thing perfectly apparent to him; yet he did not understand that the machinery of the mind can only transform knowledge, but never originate it, unless it be fed with facts of observation. He thus missed the most essential point of the Cartesian philosophy, which is, that to accept propositions which seem perfectly evident to us is a thing which, whether it be logical or illogical, we cannot help doing. Instead of regarding the matter in this way, he sought to reduce the first principles of science to formulas which cannot be denied without self-contradiction, and was apparently unaware of the great

difference between his position and that of Descartes. So he reverted to the old formalities of logic, and, above all, abstract definitions played a great part in his philosophy. It was quite natural, therefore, that on observing that the method of Descartes labored under the difficulty that we may seem to ourselves to have clear apprehensions of ideas which in truth are very hazy, no better remedy occurred to him than to require an abstract definition of every important term. Accordingly, in adopting the distinction of *clear* and *distinct* notions, he described the latter quality as the clear apprehension of everything contained in the definition; and the books have ever since copied his words. There is no danger that his chimerical scheme will ever again be overvalued. Nothing new can ever be learned by analyzing definitions. Nevertheless, our existing beliefs can be set in order by this process, and order is an essential element of intellectual economy, as of every other. It may be acknowledged, therefore, that the books are right in making familiarity with a notion the first step toward clearness of apprehension, and the defining of it the second. But in omitting all mention of any higher perspicuity of thought, they simply mirror a philosophy which was exploded a hundred years ago. That much-admired "ornament of logic"—the doctrine of clearness and distinctness—may be pretty enough, but it is high time to relegate to our cabinet of curiosities the antique *bijou*, and to wear about us something better adapted to modern uses.

The very first lesson that we have a right to demand that logic shall teach us is, how to make our ideas clear; and a most important one it is, depreciated only by minds who stand in need of it. To know what we think, to be masters of our own meaning, will make a solid foundation for great and weighty thought. It is most easily learned by those whose ideas are meagre and restricted; and far happier they than such as wallow helplessly in a rich mud of conceptions. A nation, it is true, may, in the course of generations, overcome the disadvantage of an excessive wealth of language and its natural concomitant, a vast, unfathomable deep of ideas. We may see it in history, slowly perfecting its literary forms, sloughing at length its metaphysics, and, by virtue of the untirable patience which is often a compensation, attaining great excellence in every branch ef mental acquirement. The page of history is not yet unrolled which is to tell us whether such a people will or will not in the long-run prevail over one whose ideas (like the words of their language) are few, but which possesses a wonderful mastery over those which it has. For an individual, however, there can be no question that a few clear ideas are worth more than many confused ones. A young man would hardly be persuaded to sacrifice the greater part of his thoughts to save the rest; and the muddled head is the least apt to see the necessity of such a sacrifice. Him we can usually only commiserate, as a person with a congenital defect. Time will help him, but intellectual

maturity with regard to clearness comes rather late, an unfortunate arrangement of Nature, inasmuch as clearness is of less use to a man settled in life, whose errors have in great measure had their effect, than it would be to one whose path lies before him. It is terrible to see how a single unclear idea, a single formula without meaning, lurking in a young man's head, will sometimes act like an obstruction of inert matter in an artery, hindering the nutrition of the brain, and condemning its victim to pine away in the fullness of his intellectual vigor and in the midst of intellectual plenty. Many a man has cherished for years as his hobby some vague shadow of an idea, too meaningless to be positively false; he has, nevertheless, passionately loved it, has made it his companion by day and by night, and has given to it his strength and his life, leaving all other occupations for its sake, and in short has lived with it and for it, until it has become, as it were, flesh of his flesh and bone of his bone; and then he has waked up some bright morning to find it gone, clean vanished away like the beautiful Melusina of the fable, and the essence of his life gone with it. I have myself known such a man; and who can tell how many histories of circle-squarers, metaphysicians, astrologers, and what not, may not be told in the old German story?

## II.

The principles set forth in the first of these papers lead, at once, to a method of reaching a clearness of thought of a far higher grade than the "distinctness" of the logicians. We have there found that the action of thought is excited by the irritation of doubt, and ceases when belief is attained; so that the production of belief is the sole function of thought. All these words, however, are too strong for my purpose. It is as if I had described the phenomena as they appear under a mental microscope. Doubt and Belief, as the words are commonly employed, relate to religious or other grave discussions. But here I use them to designate the starting of any question, no matter how small or how great, and the resolution of it. If, for instance, in a horse-car, I pull out my purse and find a five-cent nickel and five coppers, I decide, while my hand is going to the purse, in which way I will pay my fare. To call such a question Doubt, and my decision Belief, is certainly to use words very disproportionate to the occasion. To speak of such a doubt as causing an irritation which needs to be appeased, suggests a temper which is uncomfortable to the verge of insanity. Yet, looking at the matter minutely, it must be admitted that, if there is the least hesitation as to whether I shall pay the five coppers or the nickel (as there will be sure to be, unless I act from some previously contracted habit in the matter), though irritation is too strong a word, yet I am excited to such small mental activity as may be necessary to deciding how I shall act. Most frequently

doubts arise from some indecision, however momentary, in our action. Sometimes it is not so. I have, for example, to wait in a railway-station, and to pass the time I read the advertisements on the walls, I compare the advantages of different trains and different routes which I never expect to take, merely fancying myself to be in a state of hesitancy, because I am bored with having nothing to trouble me. Feigned hesitancy, whether feigned for mere amusement or with a lofty purpose, plays a great part in the production of scientific inquiry. However the doubt may originate, it stimulates the mind to an activity which may be slight or energetic, calm or turbulent. Images pass rapidly through consciousness, one incessantly melting into another, until at last, when all is over—it may be in a fraction of a second, in an hour, or after long years—we find ourselves decided as to how we should act under such circumstances as those which occasioned our hesitation. In other words, we have attained belief.

In this process we observe two sorts of elements of consciousness, the distinction between which may best be made clear by means of an illustration. In a piece of music there are the separate notes, and there is the air. A single tone may be prolonged for an hour or a day, and it exists as perfectly in each second of that time as in the whole taken together; so that, as long as it is sounding, it might be present to a sense from which everything in the past was as completely absent as the future itself. But it is different with the air, the performance of which occupies a certain time, during the portions of which only portions of it are played. It consists in an orderliness in the succession of sounds which strike the ear at different times; and to perceive it there must be some continuity of consciousness which makes the events of a lapse of time present to us. We certainly only perceive the air by hearing the separate notes; yet we cannot be said to directly hear it, for we hear only what is present at the instant, and an orderliness of succession cannot exist in an instant. These two sorts of objects, what we are *immediately* conscious of and what we are *mediately* conscious of, are found in all consciousness. Some elements (the sensations) are completely present at every instant so long as they last, while others (like thought) are actions having beginning, middle, and end, and consist in a congruence in the succession of sensations which flow through the mind. They cannot be immediately present to us, but must cover some portion of the past or future. Thought is a thread of melody running through the succession of our sensations.

We may add that just as a piece of music may be written in parts, each part having its own air, so various systems of relationship of succession subsist together between the same sensations. These different systems are distinguished by having different motives, ideas, or functions. Thought is only one such system, for its sole motive, idea, and function, is to produce belief, and whatever does

not concern that purpose belongs to some other system of relations. The action of thinking may incidentally have other results; it may serve to amuse us, for example, and among *dilettanti* it is not rare to find those who have so perverted thought to the purposes of pleasure that it seems to vex them to think that the questions upon which they delight to exercise it may ever get finally settled; and a positive discovery which takes a favorite subject out of the arena of literary debate is met with ill-concealed dislike. This disposition is the very debauchery of thought. But the soul and meaning of thought, abstracted from the other elements which accompany it, though it may be voluntarily thwarted, can never be made to direct itself toward anything but the production of belief. Thought in action has for its only possible motive the attainment of thought at rest; and whatever does not refer to belief is no part of the thought itself.

And what, then, is belief? It is the demi-cadence which closes a musical phrase in the symphony of our intellectual life. We have seen that it has just three properties: First, it is something that we are aware of; second, it appeases the irritation of doubt; and, third, it involves the establishment in our nature of a rule of action, or, say for short, a *habit*. As it appeases the irritation of doubt, which is the motive for thinking, thought relaxes, and comes to rest for a moment when belief is reached. But, since belief is a rule for action, the application of which involves further doubt and further thought, at the same time that it is a stopping-place, it is also a new starting-place for thought. That is why I have permitted myself to call it thought at rest, although thought is essentially an action. The *final* upshot of thinking is the exercise of volition, and of this thought no longer forms a part; but belief is only a stadium of mental action, an effect upon our nature due to thought, which will influence future thinking.

The essence of belief is the establishment of a habit, and different beliefs are distinguished by the different modes of action to which they give rise. If beliefs do not differ in this respect, if they appease the same doubt by producing the same rule of action, then no mere differences in the manner of consciousness of them can make them different beliefs, any more than playing a tune in different keys is playing different tunes. Imaginary distinctions are often drawn between beliefs which differ only in their mode of expression;—the wrangling which ensues is real enough, however. To believe that any objects are arranged as in Fig. 1, and to believe that they are arranged in Fig. 2, are one and the same belief; yet it is conceivable that a man should assert one proposition and deny the other. Such false distinctions do as much harm as the confusion of beliefs really different, and are among the pitfalls of which we ought constantly to beware, especially when we are upon metaphysical ground. One singular deception of this sort, which often occurs, is to mistake the sensation

produced by our own unclearness of thought for a character of the object we are thinking. Instead of perceiving that the obscurity is purely subjective, we fancy that we contemplate a quality of the object which is essentially mysterious; and if our conception be afterward presented to us in a clear form we do not recognize it as the same, owing to the absence of the feeling of unintelligibility. So

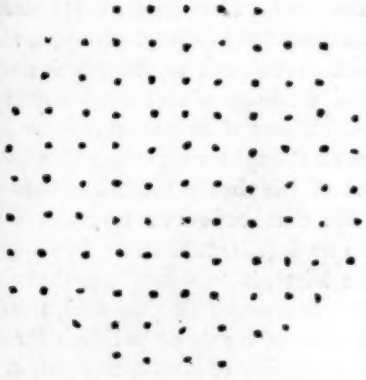

FIG. 1.

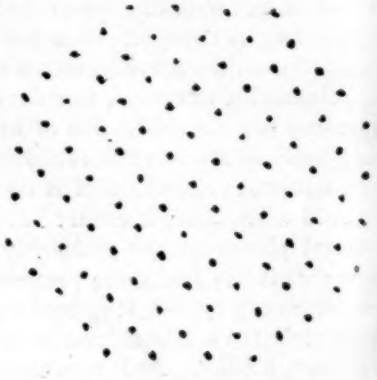

FIG. 2.

long as this deception lasts, it obviously puts an impassable barrier in the way of perspicuous thinking; so that it equally interests the opponents of rational thought to perpetuate it, and its adherents to guard against it.

Another such deception is to mistake a mere difference in the grammatical construction of two words for a distinction between the ideas they express. In this pedantic age, when the general mob of writers attend so much more to words than to things, this error is common enough. When I just said that thought is an *action*, and that it consists in a *relation*, although a person performs an action but not a relation, which can only be the result of an action, yet there was no inconsistency in what I said, but only a grammatical vagueness.

From all these sophisms we shall be perfectly safe so long as we reflect that the whole function of thought is to produce habits of action; and that whatever there is connected with a thought, but irrelevant to its purpose, is an accretion to it, but no part of it. If there be a unity among our sensations which has no reference to how we shall act on a given occasion, as when we listen to a piece of music, why we do not call that thinking. To develop its meaning, we have, therefore, simply to determine what habits it produces, for what a thing means is simply what habits it involves. Now, the identity of a habit depends on how it might lead us to act, not merely under such circumstances as are likely to arise, but under such as might possibly

occur, no matter how improbable they may be. What the habit is depends on *when* and *how* it causes us to act. As for the *when*, every stimulus to action is derived from perception; as for the *how*, every purpose of action is to produce some sensible result. Thus, we come down to what is tangible and practical, as the root of every real distinction of thought, no matter how subtile it may be; and there is no distinction of meaning so fine as to consist in anything but a possible difference of practice.

To see what this principle leads to, consider in the light of it such a doctrine as that of transubstantiation. The Protestant churches generally hold that the elements of the sacrament are flesh and blood only in a tropical sense; they nourish our souls as meat and the juice of it would our bodies. But the Catholics maintain that they are literally just that; although they possess all the sensible qualities of wafer-cakes and diluted wine. But we can have no conception of wine except what may enter into a belief, either—

1. That this, that, or the other, is wine; or,
2. That wine possesses certain properties.

Such beliefs are nothing but self-notifications that we should, upon occasion, act in regard to such things as we believe to be wine according to the qualities which we believe wine to possess. The occasion of such action would be some sensible perception, the motive of it to produce some sensible result. Thus our action has exclusive reference to what affects the senses, our habit has the same bearing as our action, our belief the same as our habit, our conception the same as our belief; and we can consequently mean nothing by wine but what has certain effects, direct or indirect, upon our senses; and to talk of something as having all the sensible characters of wine, yet being in reality blood, is senseless jargon. Now, it is not my object to pursue the theological question; and having used it as a logical example I drop it, without caring to anticipate the theologian's reply. I only desire to point out how impossible it is that we should have an idea in our minds which relates to anything but conceived sensible effects of things. Our idea of anything *is* our idea of its sensible effects; and if we fancy that we have any other we deceive ourselves, and mistake a mere sensation accompanying the thought for a part of the thought itself. It is absurd to say that thought has any meaning unrelated to its only function. It is foolish for Catholics and Protestants to fancy themselves in disagreement about the elements of the sacrament, if they agree in regard to all their sensible effects, here or hereafter.

It appears, then, that the rule for attaining the third grade of clearness of apprehension is as follows: Consider what effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object.

III.

Let us illustrate this rule by some examples; and, to begin with the simplest one possible, let us ask what we mean by calling a thing *hard*. Evidently that it will not be scratched by many other substances. The whole conception of this quality, as of every other, lies in its conceived effects. There is absolutely no difference between a hard thing and a soft thing so long as they are not brought to the test. Suppose, then, that a diamond could be crystallized in the midst of a cushion of soft cotton, and should remain there until it was finally burned up. Would it be false to say that that diamond was soft? This seems a foolish question, and would be so, in fact, except in the realm of logic. There such questions are often of the greatest utility as serving to bring logical principles into sharper relief than real discussions ever could. In studying logic we must not put them aside with hasty answers, but must consider them with attentive care, in order to make out the principles involved. We may, in the present case, modify our question, and ask what prevents us from saying that all hard bodies remain perfectly soft until they are touched, when their hardness increases with the pressure until they are scratched. Reflection will show that the reply is this: there would be no *falsity* in such modes of speech. They would involve a modification of our present usage of speech with regard to the words hard and soft, but not of their meanings. For they represent no fact to be different from what it is; only they involve arrangements of facts which would be exceedingly maladroit. This leads us to remark that the question of what would occur under circumstances which do not actually arise is not a question of fact, but only of the most perspicuous arrangement of them. For example, the question of free-will and fate in its simplest form, stripped of verbiage, is something like this: I have done something of which I am ashamed; could I, by an effort of the will, have resisted the temptation, and done otherwise? The philosophical reply is, that this is not a question of fact, but only of the arrangement of facts. Arranging them so as to exhibit what is particularly pertinent to my question—namely, that I ought to blame myself for having done wrong—it is perfectly true to say that, if I had willed to do otherwise than I did, I should have done otherwise. On the other hand, arranging the facts so as to exhibit another important consideration, it is equally true that, when a temptation has once been allowed to work, it will, if it has a certain force, produce its effect, let me struggle how I may. There is no objection to a contradiction in what would result from a false supposition. The *reductio ad absurdum* consists in showing that contradictory results would follow from a hypothesis which is consequently judged to be false. Many questions are involved in the free-will discussion, and I am far from desiring to say that both sides are equally right. On the contrary, I am of opinion

that one side denies important facts, and that the other does not. But what I do say is, that the above single question was the origin of the whole doubt; that, had it not been for this question, the controversy would never have arisen; and that this question is perfectly solved in the manner which I have indicated.

Let us next seek a clear idea of Weight. This is another very easy case. To say that a body is heavy means simply that, in the absence of opposing force, it will fall. This (neglecting certain specifications of how it will fall, etc., which exist in the mind of the physicist who uses the word) is evidently the whole conception of weight. It is a fair question whether some particular facts may not *account* for gravity; but what we mean by the force itself is completely involved in its effects.

This leads us to undertake an account of the idea of Force in general. This is the great conception which, developed in the early part of the seventeenth century from the rude idea of a cause, and constantly improved upon since, has shown us how to explain all the changes of motion which bodies experience, and how to think about all physical phenomena; which has given birth to modern science, and changed the face of the globe; and which, aside from its more special uses, has played a principal part in directing the course of modern thought, and in furthering modern social development. It is, therefore, worth some pains to comprehend it. According to our rule, we must begin by asking what is the immediate use of thinking about force; and the answer is, that we thus account for changes of motion. If bodies were left to themselves, without the intervention of forces, every motion would continue unchanged both in velocity and in direction. Furthermore, change of motion never takes place abruptly; if its direction is changed, it is always through a curve without angles; if its velocity alters, it is by degrees. The gradual changes which are constantly taking place are conceived by geometers to be compounded together according to the rules of the parallelogram of forces. If the reader does not already know what this is, he will find it, I hope, to his advantage to endeavor to follow the following explanation; but if mathematics are insupportable to him, pray let him skip three paragraphs rather than that we should part company here.

A *path* is a line whose beginning and end are distinguished. Two paths are considered to be equivalent, which, beginning at the same point, lead to the same point. Thus the two paths, *A B C D E* and *A F G H E*, are equivalent. Paths which do *not* begin at the same point are considered to be equivalent, provided that, on moving either of them without turning it, but keeping it always parallel to its original position, when its beginning coincides with that of the other path, the ends also coincide. Paths are considered as geometrically added together, when one begins where the other ends; thus the path *A E* is conceived to be a sum of *A B*, *B C*, *C D*, and *D E*. In the paral-

lelogram of Fig. 4 the diagonal *A C* is the sum of *A B* and *B C*; or, since *A D* is geometrically equivalent to *B C*, *A C* is the geometrical sum of *A B* and *A D*.

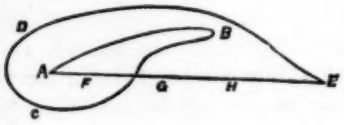


Fig. 3.

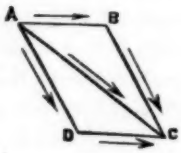


Fig. 4.

All this is purely conventional. It simply amounts to this: that we choose to call paths having the relations I have described equal or added. But, though it is a convention, it is a convention with a good reason. The rule for geometrical addition may be applied not only to paths, but to any other things which can be represented by paths. Now, as a path is determined by the varying direction and distance of the point which moves over it from the starting-point, it follows that anything which from its beginning to its end is determined by a varying direction and a varying magnitude is capable of being represented by a line. Accordingly, *velocities* may be represented by lines, for they have only directions and rates. The same thing is true of *accelerations*, or changes of velocities. This is evident enough in the case of velocities; and it becomes evident for accelerations if we consider that precisely what velocities are to positions—namely, states of change of them—that accelerations are to velocities.

The so-called "parallelogram of forces" is simply a rule for compounding accelerations. The rule is, to represent the accelerations by paths, and then to geometrically add the paths. The geometers, however, not only use the "parallelogram of forces" to compound different accelerations, but also to resolve one acceleration into a sum of several. Let *A B* (Fig. 5) be the path which represents a certain acceleration—say, such a change in the motion of a body that at the end of one second the body will, under the influence of that change, be in a position different from what it would have had if its motion had continued unchanged such that a path equivalent to *A B* would lead from the latter position to the former. This acceleration may be considered as the sum of the accelerations represented by *A C* and *C B*. It may also be considered as the sum of the very different accelerations represented by *A D* and *D B*, where *A D* is almost the opposite of *A C*. And it is clear that there is an immense variety of

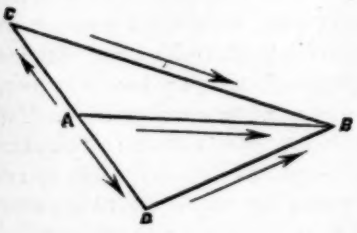


Fig. 5.

ways in which *A B* might be resolved into the sum of two accelerations.

After this tedious explanation, which I hope, in view of the extraordinary interest of the conception of force, may not have exhausted the reader's patience, we are prepared at last to state the grand fact which this conception embodies. This fact is that if the actual changes of motion which the different particles of bodies experience are each resolved in its appropriate way, each component acceleration is precisely such as is prescribed by a certain law of Nature, according to which bodies in the relative positions which the bodies in question actually have at the moment,[1] always receive certain accelerations, which, being compounded by geometrical addition, give the acceleration which the body actually experiences.

This is the only fact which the idea of force represents, and whoever will take the trouble clearly to apprehend what this fact is, perfectly comprehends what force is. Whether we ought to say that a force *is* an acceleration, or that it *causes* an acceleration, is a mere question of propriety of language, which has no more to do with our real meaning than the difference between the French idiom "*Il fait froid*" and its English equivalent "*It is cold.*" Yet it is surprising to see how this simple affair has muddled men's minds. In how many profound treatises is not force spoken of as a "mysterious entity," which seems to be only a way of confessing that the author despairs of ever getting a clear notion of what the word means! In a recent admired work on "Analytic Mechanics" it is stated that we understand precisely the effect of force, but what force itself is we do not understand! This is simply a self-contradiction. The idea which the word force excites in our minds has no other function than to affect our actions, and these actions can have no reference to force otherwise than through its effects. Consequently, if we know what the effects of force are, we are acquainted with every fact which is implied in saying that a force exists, and there is nothing more to know. The truth is, there is some vague notion afloat that a question may mean something which the mind cannot conceive; and when some hair-splitting philosophers have been confronted with the absurdity of such a view, they have invented an empty distinction between positive and negative conceptions, in the attempt to give their non-idea a form not obviously nonsensical. The nullity of it is sufficiently plain from the considerations given a few pages back; and, apart from those considerations, the quibbling character of the distinction must have struck every mind accustomed to real thinking.

## IV.

Let us now approach the subject of logic, and consider a conception which particularly concerns it, that of *reality*. Taking clearness

[1] Possibly the velocities also have to be taken into account.

in the sense of familiarity, no idea could be clearer than this. Every child uses it with perfect confidence, never dreaming that he does not understand it. As for clearness in its second grade, however, it would probably puzzle most men, even among those of a reflective turn of mind, to give an abstract definition of the real. Yet such a definition may perhaps be reached by considering the points of difference between reality and its opposite, fiction. A figment is a product of somebody's imagination; it has such characters as his thought impresses upon it. That whose characters are independent of how you or I think is an external reality. There are, however, phenomena within our own minds, dependent upon our thought, which are at the same time real in the sense that we really think them. But though their characters depend on how we think, they do not depend on what we think those characters to be. Thus, a dream has a real existence as a mental phenomenon, if somebody has really dreamt it; that he dreamt so and so, does not depend on what anybody thinks was dreamt, but is completely independent of all opinion on the subject. On the other hand, considering, not the fact of dreaming, but the thing dreamt, it retains its peculiarities by virtue of no other fact than that it was dreamt to possess them. Thus we may define the real as that whose characters are independent of what anybody may think them to be.

But, however satisfactory such a definition may be found, it would be a great mistake to suppose that it makes the idea of reality perfectly clear. Here, then, let us apply our rules. According to them, reality, like every other quality, consists in the peculiar sensible effects which things partaking of it produce. The only effect which real things have is to cause belief, for all the sensations which they excite emerge into consciousness in the form of beliefs. The question therefore is, how is true belief (or belief in the real) distinguished from false belief (or belief in fiction). Now, as we have seen in the former paper, the ideas of truth and falsehood, in their full development, appertain exclusively to the scientific method of settling opinion. A person who arbitrarily chooses the propositions which he will adopt can use the word truth only to emphasize the expression of his determination to hold on to his choice. Of course, the method of tenacity never prevailed exclusively; reason is too natural to men for that. But in the literature of the dark ages we find some fine examples of it. When Scotus Erigena is commenting upon a poetical passage in which hellebore is spoken of as having caused the death of Socrates, he does not hesitate to inform the inquiring reader that Helleborus and Socrates were two eminent Greek philosophers, and that the latter having been overcome in argument by the former took the matter to heart and died of it! What sort of an idea of truth could a man have who could adopt and teach, without the qualification of a perhaps, an opinion taken so entirely at random? The real spirit of Socrates, who I hope would have been delighted to have been "overcome in argu-

ment," because he would have learned something by it, is in curious contrast with the naïve idea of the glossist, for whom discussion would seem to have been simply a struggle. When philosophy began to awake from its long slumber, and before theology completely dominated it, the practice seems to have been for each professor to seize upon any philosophical position he found unoccupied and which seemed a strong one, to intrench himself in it, and to sally forth from time to time to give battle to the others. Thus, even the scanty records we possess of those disputes enable us to make out a dozen or more opinions held by different teachers at one time concerning the question of nominalism and realism. Read the opening part of the "Historia Calamitatum" of Abelard, who was certainly as philosophical as any of his contemporaries, and see the spirit of combat which it breathes. For him, the truth is simply his particular stronghold. When the method of authority prevailed, the truth meant little more than the Catholic faith. All the efforts of the scholastic doctors are directed toward harmonizing their faith in Aristotle and their faith in the Church, and one may search their ponderous folios through without finding an argument which goes any further. It is noticeable that where different faiths flourish side by side, renegades are looked upon with contempt even by the party whose belief they adopt; so completely has the idea of loyalty replaced that of truth-seeking. Since the time of Descartes, the defect in the conception of truth has been less apparent. Still, it will sometimes strike a scientific man that the philosophers have been less intent on finding out what the facts are, than on inquiring what belief is most in harmony with their system. It is hard to convince a follower of the *a priori* method by adducing facts; but show him that an opinion he is defending is inconsistent with what he has laid down elsewhere, and he will be very apt to retract it. These minds do not seem to believe that disputation is ever to cease; they seem to think that the opinion which is natural for one man is not so for another, and that belief will, consequently, never be settled. In contenting themselves with fixing their own opinions by a method which would lead another man to a different result, they betray their feeble hold of the conception of what truth is.

On the other hand, all the followers of science are fully persuaded that the processes of investigation, if only pushed far enough, will give one certain solution to every question to which they can be applied. One man may investigate the velocity of light by studying the transits of Venus and the aberration of the stars; another by the oppositions of Mars and the eclipses of Jupiter's satellites; a third by the method of Fizeau; a fourth by that of Foucault; a fifth by the motions of the curves of Lissajoux; a sixth, a seventh, an eighth, and a ninth, may follow the different methods of comparing the measures of statical and dynamical electricity. They may at first obtain different results, but, as each perfects his method and his processes, the

results will move steadily together toward a destined centre. So with all scientific research. Different minds may set out with the most antagonistic views, but the progress of investigation carries them by a force outside of themselves to one and the same conclusion. This activity of thought by which we are carried, not where we wish, but to a foreordained goal, is like the operation of destiny. No modification of the point of view taken, no selection of other facts for study, no natural bent of mind even, can enable a man to escape the predestinate opinion. This great law is embodied in the conception of truth and reality. The opinion which is fated[1] to be ultimately agreed to by all who investigate, is what we mean by the truth, and the object represented in this opinion is the real. That is the way I would explain reality.

But it may be said that this view is directly opposed to the abstract definition which we have given of reality, inasmuch as it makes the characters of the real to depend on what is ultimately thought about them. But the answer to this is that, on the one hand, reality is independent, not necessarily of thought in general, but only of what you or I or any finite number of men may think about it; and that, on the other hand, though the object of the final opinion depends on what that opinion is, yet what that opinion is does not depend on what you or I or any man thinks. Our perversity and that of others may indefinitely postpone the settlement of opinion; it might even conceivably cause an arbitrary proposition to be universally accepted as long as the human race should last. Yet even that would not change the nature of the belief, which alone could be the result of investigation carried sufficiently far; and if, after the extinction of our race, another should arise with faculties and disposition for investigation, that true opinion must be the one which they would ultimately come to. "Truth crushed to earth shall rise again," and the opinion which would finally result from investigation does not depend on how anybody may actually think. But the reality of that which is real does depend on the real fact that investigation is destined to lead, at last, if continued long enough, to a belief in it.

But I may be asked what I have to say to all the minute facts of history, forgotten never to be recovered, to the lost books of the ancients, to the buried secrets.

> "Full many a gem of purest ray serene
> The dark, unfathomed caves of ocean bear;
> Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air."

Do these things not really exist because they are hopelessly beyond

[1] Fate means merely that which is sure to come true, and can nohow be avoided. It is a superstition to suppose that a certain sort of events are ever fated, and it is another to suppose that the word fate can never be freed from its superstitious taint. We are all fated to die.

the reach of our knowledge? And then, after the universe is dead (according to the prediction of some scientists), and all life has ceased forever, will not the shock of atoms continue though there will be no mind to know it? To this I reply that, though in no possible state of knowledge can any number be great enough to express the relation between the amount of what rests unknown to the amount of the known, yet it is unphilosophical to suppose that, with regard to any given question (which has any clear meaning), investigation would not bring forth a solution of it, if it were carried far enough. Who would have said, a few years ago, that we could ever know of what substances stars are made whose light may have been longer in reaching us than the human race has existed? Who can be sure of what we shall not know in a few hundred years? Who can guess what would be the result of continuing the pursuit of science for ten thousand years, with the activity of the last hundred? And if it were to go on for a million, or a billion, or any number of years you please, how is it possible to say that there is any question which might not ultimately be solved?

But it may be objected, "Why make so much of these remote considerations, especially when it is your principle that only practical distinctions have a meaning?" Well, I must confess that it makes very little difference whether we say that a stone on the bottom of the ocean, in complete darkness, is brilliant or not—that is to say, that it *probably* makes no difference, remembering always that that stone *may* be fished up to-morrow. But that there are gems at the bottom of the sea, flowers in the untraveled desert, etc., are propositions which, like that about a diamond being hard when it is not pressed, concern much more the arrangement of our language than they do the meaning of our ideas.

It seems to me, however, that we have, by the application of our rule, reached so clear an apprehension of what we mean by reality, and of the fact which the idea rests on, that we should not, perhaps, be making a pretension so presumptuous as it would be singular, if we were to offer a metaphysical theory of existence for universal acceptance among those who employ the scientific method of fixing belief. However, as metaphysics is a subject much more curious than useful, the knowledge of which, like that of a sunken reef, serves chiefly to enable us to keep clear of it, I will not trouble the reader with any more Ontology at this moment. I have already been led much further into that path than I should have desired; and I have given the reader such a dose of mathematics, psychology, and all that is most abstruse, that I fear he may already have left me, and that what I am now writing is for the compositor and proof-reader exclusively. I trusted to the importance of the subject. There is no royal road to logic, and really valuable ideas can only be had at the price of close attention. But I know that in the matter of ideas the public prefer

the cheap and nasty; and in my next paper I am going to return to the easily intelligible, and not wander from it again. The reader who has been at the pains of wading through this month's paper, shall be rewarded in the next one by seeing how beautifully what has been developed in this tedious way can be applied to the ascertainment of the rules of scientific reasoning.

We have, hitherto, not crossed the threshold of scientific logic. It is certainly important to know how to make our ideas clear, but they may be ever so clear without being true. How to make them so, we have next to study. How to give birth to those vital and procreative ideas which multiply into a thousand forms and diffuse themselves everywhere, advancing civilization and making the dignity of man, is an art not yet reduced to rules, but of the secret of which the history of science affords some hints.

## THE ARCHER-FISHES.[1]

By E. SAUVAGE.

IN the elegance and variety of their colors, in the splendor and brilliancy of the tints with which they have been adorned by Nature, marine animals have no reason to envy the inhabitants of air; and if in the tropical regions of Africa and America the forests are embellished by the presence of innumerable birds of gorgeous plumage, the Indian Ocean and the Antilles Sea possess countless legions of fishes that are more beautiful still, whose scales flash with all the colors of the metals and precious stones, while a thousand varied ornamentations are traced in vivid colors on the general tone.

The animals known to our colonists on the Antilles Islands under the names of *Demoiselles*, *Portugais*, *Bandoulières*, are, in this respect, not inferior to the most richly-adorned of fishes. Accustomed to keep near the shore, amid the rocks and in shallow waters, swimming swiftly and ever moving, they are constantly reflecting the splendid colors with which they are decorated. Rose-color, purple, azure, velvety-black, milk-white, are gorgeously displayed on their surface, in the form of bands, streaks, curved lines running in various directions, rings, ocellated spots. These colors stand out boldly on the surface of the body, which furnishes a background of the richest nacreous tints of gold and silver, or of polished steel.

In all of these fishes the body is compressed, and the vertical fins are covered with scales, whence the name *Squamipinnes*, by which they are known to naturalists. The shape of the body is sometimes peculiar, and the buffalo or cow fish of the Malays is one of the most

[1] Translated from the French, by J. Fitzgerald, A. M.

curious of the class, as well by reason of the protuberance and the sharp, recurved horns of the head, and the compressed and unequal spines of the back, as on account of the broad, yellow, green, and brown *zebraizations* which adorn the body. The jaws sometimes are armed with minute teeth like the nap of velvet, as in the archer-fish; sometimes these teeth are superseded by fine, compact, silky filaments, performing the same functions as the barbs of the whale—they serve to strain the water and to retain the little animals on which the fish preys. The fishes of this class are the *Chætodon*, with its rich colors; the *Holacanthus*, which is perhaps the most beautiful member of the family; the *Pomacanthus*, known to our French colonists as *Le Portugais* (the Portuguese); and sundry others.

Of the *Chætodons*, some have the muzzle long and slender, formed by the bones of the jaw, which are united along nearly their entire length by a membrane, so that the mouth is simply an horizontal slit at the extremity of this cylinder, or elongated cone. The vertical diameter of the body is very great, and the upright fin of the back is high and scaly; the tail is cut square; the profile, which is concave in front of the eyes, rises almost vertically, so that the snout is about one-fourth the depth of the head. These fishes, known under the name of *Chelmons*, inhabit the Indian Ocean; naturalists distinguish two species, the beaked *Chelmon* and the long-beaked *Chelmon* (*see* the latter in Fig. 1). These species differ from each other not only in length of beak, but also in the arrangement of the colors which adorn them.

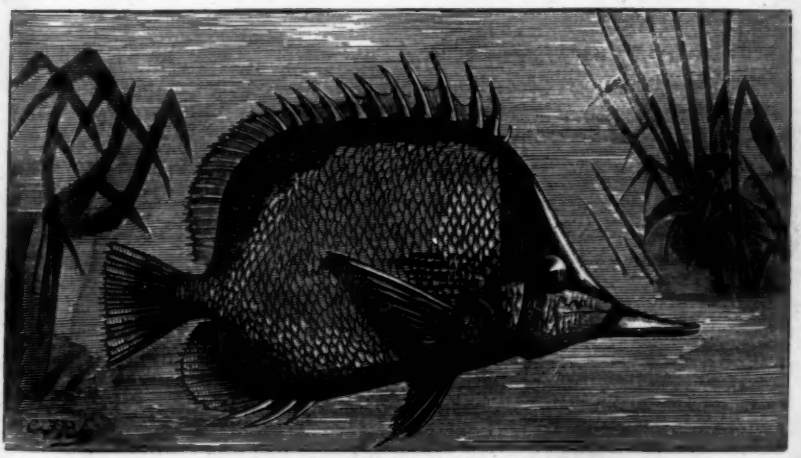

Fig. 1.

In the beaked *Chelmon* the body is greenish and iridescent; the fins are green, with reflection of azure; a black spot, surrounded by a pearl-white circle, is seen on the dorsal fin, in length about one-third that of the soft rays; five vertical stripes of azure-color, and

bordered with a nacreous white line, adorn the body; one of these stripes crosses the eye obliquely; a second one, bisecting the nape of the neck, extends to the ventral fins; the next two mark the flanks, and the posterior stripe bisects the root of the caudal fin.

The long-beaked *Chelmon's* body is yellow. Instead of the stripe crossing the eye, seen in the other species, we find on the anterior portion of the body a broad, blackish spot, triangular in shape, and terminating in a point on the snout. This spot is bordered by a nacreous white stripe; the forehead is of azure tint, with a shade of sea-green; the eye is of a pure rose-color; a narrow stripe of black adorns the margin of the fins, which themselves are of mauve-color; on the posterior part of the anal fin, near its edge, is seen a deep-black spot, encircled by a line of pearly white.

The *Chelmon*, particularly the beaked *Chelmon*, has been described by Schlosser, under the title of Archer-fish, in the "Philosophical Transactions." The animal is said to obtain its food in a peculiar way, and hence the names given to it by Schlosser (*Jaculator*) and by the Dutch colonists of the East Indies (*Spuytvisch*, pump-fish or spitting-fish).

Lacépède, following the narratives of travelers, tells us that the long-beaked *Chætodon* "usually keeps near to the mouths of rivers, and especially frequents places where the water is not deep. It feeds on insects, especially such as live on the marine plants which rise above the surface of the sea. In taking them it resorts to a noteworthy manœuvre, which it is enabled to perform by the very elongated form of the snout; and a similar sort of manœuvre is performed by the *Sparus insidator*, the bellows-chætodon, and other fishes, with very long, very narrow, and nearly cylindrical beak, like that of the animal we are now describing. When the archer espies an insect which it wishes to seize, but which is flying too high above the surface to be captured by leaping out of the water, it approaches as near as possible to its prey, then it fills its mouth-cavity with water, shuts its gill-openings, suddenly compresses its little slit of a mouth, and, ejecting rapidly the water through the very narrow tube which forms its snout, squirts it often to the distance of two metres, and that with such force that the insect is stunned and falls into the sea. The performance is so amusing that rich people throughout the greater part of the East Indies keep long-beaked *Chætodons* in large vessels."

Bloch, in his "History of Fishes," which was published at the close of the last century, tells us, on the authority of Mynheer Hommel, inspector of the Batavia Hospital, that the bandoulière or beaked *Chætodon* has a very singular way of procuring food. "Observe," says Bloch, "how this fish ensnares the flies it discovers on the marine plants which project above the water. It approaches within four to six feet of the insect, and then squirts water upon it with such force that it never fails to bring it down and make it its prey." Mynheer

Hommel himself made the following experiment: He had a few of these fishes placed in a large vessel containing sea-water. When they had become accustomed to this prison, he ran a pin through a fly, and made it fast to one side of the vessel. He then was so fortunate as to see "these fishes vying with one another in their efforts to seize the fly, and continually squirting little drops of water, without ever missing their aim."

We owe it to truth to add that Bleeker, who resided so long in the Dutch Indies, and who is perfectly familiar with the ichthyological fauna of that region, not only finds in the habits of the bandoulière no confirmation of this singular method of catching insects, but he never even heard it mentioned during his sojourn at Batavia. "Certain it is," adds he, "that at Batavia this species inhabits only the waters of the reefs of the little islands in the bay, and never visits the swampy and sandy beach in the vicinity of the capital, or the mouths of the rivers."

A fish belonging to the same family—*Squamipinnes*—but classed in another group, has likewise received from Schlosser and Pallas the name of Archer.

Four species, inhabiting the waters of Polynesia and the Indian Archipelago, constitute this group of the Archers, or *Toxotæ*. Instead of being more or less oval in shape, as is the case with the *Chætodons*, the body is here elongated, the line of the back being nearly straight, while that of the belly is curved, so that the fish assumes a triangu-

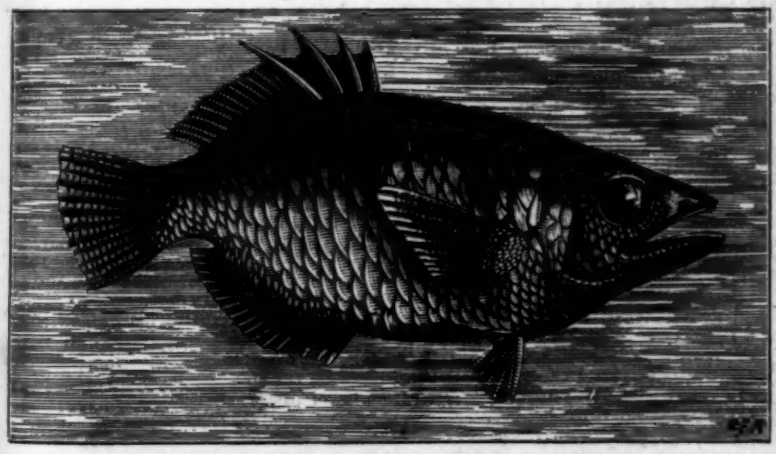

Fig. 2.

lar shape. The distinguishing feature of these fishes is the backward position of the dorsal fin, which, relegated to the posterior part of the body, is armed with only three or four spines (Fig. 2). The head, lying in the same plane with the line of the back, is pointed; the eye

is large, and the mouth opens wide. The brilliant colors of the *Chætodons*, properly so called, are here wanting; the body is olive-brown or yellow, and bears broad, round, or oblong spots, or vertical stripes of black color; the eye is rose-color and brilliant; the belly, silvery-white.

According to Cuvier and Valencienne, "though the mouth of this fish differs immensely in its organization from that of *Chelmon*, it, too, can shoot drops of water to a great height, and can hit, with almost unerring aim, insects and other little animals on aquatic plants, or even on the herbage at the water's edge. The inhabitants of sundry regions in India," add these authors, "and particularly the Chinese in Java, keep these fish in their houses for the sake of the amusement afforded by witnessing their performances, offering it ants and flies on a string, or on the end of a stick, brought within range. . . . The species is known in the Indian Archipelago under the Malay name of *ikansumpit*."

Bleeker, in a recent work on the *Toxotæ*, tells us that at Batavia this fish is no longer kept, as it appears to have been a century ago, either by Europeans or by the Chinese. He further says that neither from Chinese nor from natives, whether at Batavia or elsewhere, has he been able to obtain any confirmation of the accounts which have been given concerning its skill in seizing its prey. According to him, the celebrity enjoyed by the archer-fish is undeserved, and rests upon a misapprehension; in short, he shows from the very texts of Pallas and Schlosser that Hommel's observation applies to the long-beaked *Chelmon*, of which we have spoken above, and that like habits have been gratuitously attributed to the two species, they having been regarded as generically identical.—*La Nature*.

## TEMPERAMENTS.

By ELY VAN DE WARKER, M. D.

EVERY adult human being carries about with him an atmosphere of individuality. By this means is the gregarious animal called man enabled to preserve in himself such an isolation from the mass of his fellows that he can gain and hold whatever may be his share of prosperity and remembrance. In this individuality lie his powers of offense and defense—the buckler and spear of his *ego;* and in it also is expressed the sum of his mental and physical traits in such a manner that, once having known, we may remember him. There are two elements that enter into the formation of this distinctive and memorable quality, mental and physical. These factors enter unequally into the formation of this individual total. The element that

has really the least to do with that subtile force called character is the one by which we chiefly recognize the man. This is the *ensembled physique*, the mental picture we have formed of the bodily man; it is only by long association that we come to speak of one by his mental traits, and can recall him to our minds, not by accidents of size, shape, complexion, but by the tone, manner, and quality, of the mental man. It is curious, however, to reflect that our chief means of mutual identity are the same as those by which we distinguish horse from horse, and dog from dog; and that such is the infinite variety in the merely physical development of men, that this is sufficient for the practical affairs of life. In fact, it is not within experience that two human beings ever existed who were so nearly alike that side by side they could not be distinguished.[1] But human individuality is separated from that of the brute by the refinement of a physical quality. This is called temperament. Although temperaments are purely of physical origin, yet their outlet is mainly found in the actions or the mental habits of the individual, and thus it is that temperaments, like charity, cover a multitude of sins. Even those who believe in the immateriality and separate entity of mind, do not hesitate to ascribe the fretfulness, fickleness, temper, and other mental shortcomings of their friends, to faults of temperament. This may in a measure be the result of habit, but I believe that there is about it the force of a truth that even the most spiritual of psychologists cannot escape. It exists as a physical medium, through which the mental life shines forth, tinged and refracted by its passage. The old word expresses it, *humors* of the body, a mythical, potent, and subtile fluid, mingling with the bodily substance, and rising, exhalation-like, into the brain, obscuring, revealing, exalting, and depressing the operations of the mind according as it is acting well or ill; as hypothetical as the interplanetary ether, yet as real as a fit of the blue devils. This was somewhat the old notion, and a well-fought battle-ground it was, over which the solidists and humoralists contended right gallantly. A standpoint upon a solid basis of fact is to this day wanting from which we may say they were wrong.

Many of these old fathers in medicine fairly reveled in the idea of temperaments. It contained just enough of the mysterious to spur on their wonder-loving minds. All there was of fact about it, however, they brought out, and all that we know about it they knew. We are to this day using their terms and classification, and have added nothing to them. It stands as a fact in physiology which we have inherited from the remotest boundary of historical medicine.

The four qualities of Hippocrates were believed to be the origin of the temperaments. In moisture and dryness, in heat and cold, not as conditions of existence but as entities in life, were found the mate-

[1] There are several remarkable cases of wonderfully close resemblance and mistaken identity on record, but none that stood the test indicated in the text.

rials that either singly or together formed the temperaments. They were combined thus: hot and moist produced blood, hence the sanguine temperaments; cold and moist caused phlegm or pituita, and from this the phlegmatic or lymphatic; hot and dry produced yellow bile, and gave us the sanguine or choleric; and cold and dry caused black bile, which predominating in the body resulted in the melancholic or bilious temperament.[1] In order to understand the profound reason involved in this it must be remembered that these four primary principles of living bodies were believed to be compounded of the simple elements of Nature. Here is shadowed, dimly it is true, but from the very depths of Nature, the theory of the correlation of forces, and even evolution itself. Boerhaave was among the first who attempted to improve the classification of Hippocrates, and then followed Hoffmann, Cullen, and Haller, who, however much reason they may have had, failed to refine the rugged simplicity of the old Greek. Absurd as we may deem the incarnation of the four elements in the form of temperaments by Hippocrates to be, yet from the length of time this idea has prevailed, and the profound influence it has exerted upon science for centuries, we may believe that it possessed the soul of truth that exists in things erroneous, as Herbert Spencer says. Not until 1757 was anything like a scientific explanation given. The learned Haller was the first to give the four elements their final overthrow, and place the phenomena upon a physiological basis;[2] and even he failed to suggest any improvement in the old nomenclature. It is strong evidence of the force that exists latently in old ideas that all modern attempts to extend the scope of the Hippocratic terms have never gained credit. Dr. Gregory renamed the temperaments, and added a fifth, which he called the nervous, and which has been accepted and rejected a score of times; while it is a convenient term to use, it is true that it describes no temperament that may not be included under the old terms. Then came Dr. Pritchord, who rejected the reforms of Dr. Gregory, restored the original terms, and barely escaped calling his predecessor hard names. But the temperaments, simple as they may seem, have afforded groundwork for a separate science—not formulated deductions from dry facts, but drawn warm from the mass of living, suffering humanity. Dr. W. B. Powell spent forty years of his life in the study, and at last evolved a "human science" with ten compounds of temperaments with binary, ternary, and quaternary subdivisions.[3] If human science, as taught by Dr. Powell, be true, it ought to be the ceaseless study of every man and woman, taught along with the creed and catechism—which are the spiritual to this its earthly and carnate part—to the youngest child. Lurking in this science are more than Dantesque horrors,

[1] "De Natura Hominis," tom. ii., ed. Kühn.

[2] "Elementa Physiologiæ Corporis Humani," 1757.

[3] *Journal of Human Science*, Cincinnati, 1860.

which are liable to spring upon the most circumspect of us in the shape of physiological incest; as if in the decalogue and through the ingenuity of man there were not already more crimes than human nature can withstand, that we should be exposed to others we know not of. This physiological crime consists in the marital union of like temperaments. Human science has revealed another latent offense, called sexual incompatibility, which, so far as I know, has not yet, in its sexual guise, obtruded itself in the divorce courts. It is a standing rebuke to those who build imaginary sciences, without a foothold in the solid world of facts, that, in giving their shadowy creations to the people, they are inviting the cold scrutiny of an aggregate common-sense that never fails in time to separate the true from the false.

But temperaments have been made to play a more agreeable *rôle* in human affairs than in defining physiological crimes. In the history of this physical attribute it is interesting to cite its literary aspects. Ben Jonson devoted whole plays to the idealizations of individual temperaments, in which a peculiarity was made to play its part as a *dramatis persona*. The keen and careful analysis of the poet in character is immortalized in his play of "Every Man in his Humor." Shakespeare proved himself a good physiologist as well as a good judge of a conspirator in contrasting Cassius, "lean and hungry," with men "that are fat; sleek-headed men, and such as sleep o' nights." In the earlier English novels, temperament was given a more careful study than in the modern school of light literature. Goldsmith proved himself an enemy of the humoral pathologists in saying of Olivia, in "The Vicar of Wakefield," that the temper of woman is generally formed from the cast of her features. Fielding, in his creative novel of "Tom Jones," speaks of temperaments in such a happy vein of his inimitable philosophy, that it is worth quoting and remembering: "I make no manner of doubt," he says, "but that, in this light, we may see the imaginary future chancellor just called to the bar, the archbishop in crape, and the prime-minister at the tail of an opposition, more truly happy than those who are invested with all the power and profit of these respective offices." A more perfect description of a sanguine man was never written. Novelists, as a rule, analyze temperaments the opposite of their own in their ideal characters. Scott generally describes the bilious in his heroes and heroines, and is never purely realistic in describing the sanguine type to which he belonged. Dickens is always happier in his female characters, and they are good specimens of the sanguine. Dolly, the locksmith's daughter, is a very truthful portrait of this type; while Mark Tapley, famous as the character may be, is an atrabilious, who is continually violating his physiology by being happy under the very circumstances that bring out the unmixed misery of his class. Dickens himself was decidedly of the lymphatic—a type he rarely

attempted in his creations. Richter, in "Hesperus," gives some very perfect studies of temperament; but the court physician in that novel is represented of his own type. George Eliot never violates Nature in her female characters, who are generally described as bilious or sanguine; but the least said about her heroes the better. Deronda is surely a mistake. He is first described as a good specimen of the sturdy, bilious man, and is transformed toward the close of the book into the extreme of the sanguine.

To the scientific mind there is always something assuring when we can leave the field of speculation and enter that of fact. Here chemical analysis brings to our aid positive reasons for a classification of men and women according to temperaments. Mr. Rees,[1] quoting from the researches of M. Lecanu, gives us the material for constructing the following table. The figures are ratios to 1,000 parts of blood:

TABLE I.—Ratio of Water, Albumen, and Red Blood-Globules in the Blood of Different Temperaments.

| | SANGUINE. | LYMPHATIC. | DIFFERENCE. |
|---|---|---|---|
| | Water. | Water. | |
| Females | 793.007 | 803.710 | 10.703 |
| Males | 786.584 | 800.566 | 13.982 |
| | Albumen. | Albumen. | |
| Females | 71.264 | 68.660 | 2.604 |
| Males | 65.85 | 71.701 | 5.851 |
| | Red Globules. | Red Globules. | |
| Females | 126.990 | 117.300 | 8.874 |
| Males | 136.497 | 110.667 | 19.830 |

This proves conclusively that temperaments have their origin deep and unchangeably fixed in the organic life. Can we, in view of this, look doubtingly upon their potent influence on the current of thought and emotions? Water, plasmic material, and the red blood-globules—the oxygen-carriers of living bodies—rush to the brain in proportions fixed by the law of temperaments; to one brain more, to another less, but with differences sufficient to give vigor, vivacity, tenacity, and mental breadth to the action of one; while the other moves more slowly, its mental life obscured by the smaller proportion of mind-food.

There is one point about which the reader needs to have a clear understanding. This is the difference between temperament and idiosyncrasy. "Temperament is built in a man, as bricks compose a well," says Dr. Southey; "his idiosyncrasy is developed according to the soil in which he is planted, the conditions under which he grows, and the tendency in him to vary."[2] A man has his temperament as a birth-

[1] "On the Analysis of the Blood and Urine in Health and Disease," London, 1836.

[2] *London Lancet*, American edition, May, 1876.

right, his idiosyncrasy he acquires, changes, makes it subject to his will, or is ruled by it. The distinction is broader than this, however. Temperament is a race-attribute. It is distributed like plants according to latitude and altitude. The bilious is tropic; it thrives best near the equator. The lymphatic belongs to the races of the North. Between these polar types are distributed races that monopolize temperaments as they do their language. The Celt is sanguine, the Saxon lymphatic, the Gaul nervous, the Latin bilious. Thus, temperament is pandemic, while idiosyncrasy belongs to the individual. M. Begin calls the first "la variété organique la plus générale," and the latter "celle qui est plus restreinte."

The tendency among recent writers upon physiology is to exclude the bilious, classing it with the nervous, and making three in place of four. This is the classification of M. Michel Lévy.[1] I shall retain the bilious, as being a term too commonly used by learned and unlearned to be omitted from a popular description.

The sanguine temperament presents marked physical traits. The mean height of the male is five feet eight and a half inches, and of the female two and a half inches less. The head is small comparatively, the face is made square by a firm and angular lower jaw, the forehead is slightly sloping, the nose prominent; it has a determined, resolute, exacting look. Under thirty-five the figures of both sexes are sparely covered with fat, but withal muscular. The chest is large, measuring thirty-five inches in average girth, and the abdomen flat. The complexion is light, and is florid only by exception to the rule; the hair light, light brown, or auburn, and often curly. The mouth is usually large, the lower lip full, and the teeth are regular, with a slightly-yellow tinge, which indicates firm and lasting dentine. The sanguine are generally good eaters and drinkers. All of the vital functions are active; the large chest-room, the vigorous heart, the firm muscles, insure a bodily activity that keeps the operations of organic life in unconscious and easy motion. Digestion, assimilation, excretion, and elimination, work in harmony and with vigor.

Mentally, this type is the reflection of its physical traits. The rich blood, by its active circulation through the brain, causes vivid and active mental action. The general cast of the mind is never gloomy. The mental vision is outward rather than inward, and sees things near or remote tinted by glowing, joyous colors, as through a prism. This mental outlook never implies profound insight, or deep thought, or conscious indwelling. It is the surface of things that is studied with quick and transient glances of all that is pleasant, revolting from the difficult or painful. The sanguine man, therefore, learns quickly and knows a little of everything, and by his ready tongue and quick wit is good company—a thorough good fellow. He is brave from a sense of perfect muscular strength, loving sport and athletic games.

[1] "Traité d'Hygiène."

He is quick to anger, but soon forgets wrong; a word and a blow, and oftentimes the blow first, are the features of his wrath.

It is in medicine only that the temperaments have practical importance, if we reject Dr. Powell's new science. Sanguine people are prone to acute diseases of the inflammatory type. Apoplexy, diseases of the heart and blood-vessels, hæmorrhages, acute fevers, pneumonia, pleurisy, and closely-allied disorders, are the forms of disease generally met with. Dr. Southey assigns to this class the old idea of crises; that is, in febrile diseases, at certain times, there will be sudden losses of the fluids of the body spontaneously, by which the diseased action secures a new outlet, and this is followed by a rapid convalescence. These evacuations, if the temperament of the patient be understood, are never interfered with by the physician, as they are Nature's own efforts to throw off the disease. Rapid recovery, or a speedy fatal result, may generally be looked for among sanguine people. In this temperament the physical part of man reaches its most perfect expression; the body is here in even balance with the brain. Such a combination as that of persistent intellectual effort with a typical sanguine temperament is rare. Prof. John Wilson (Christopher North) is an example of this, and of which there is scarce another illustration in literature. This temperament, finding its purer expression in a near approach to human animalism, with soul and body adjusted and evenly poised, a happy mingling of mind and matter, must surely have been the type of the Miltonic man. The fancy cannot paint him other than this, and believe him capable of contending with the dangers, obstacles, and unrelenting hardships, of his life. Of this type have the sailors, colonists, soldiers, and explorers, generally been—all men who lead in the battle with Nature's obstacles.

In the lymphatic temperament we have a direct antithesis of the sanguine. Typically, the lymphatics are heavily framed, the limbs are clumsy and large-jointed, awkward and slow in movement. This is due to the thickness of the articular surfaces of the long bones, and this also explains the large wrists and ankles; the head is large, the face unanimated, thick-lipped, pale, and with large features, the expression listless and apathetic; the eyes are blue or gray, the hair white, blond, or light auburn, and abundant. The male figure is between five feet eight inches and six feet two inches in height, the female five feet six or nine inches high (Southey), and such are the proportions that a person of this temperament rarely meets the artistic ideal of human beauty. The texture of the flesh is soft and flabby, and generally abundant, the muscles small and slow in their development. Puberty is late in its advent; this is but a characteristic, however, of the slow and deliberate manner of the general development. Functions are slowly performed and not evenly balanced; the fluid secretions too abundant, the absorbents inactive

in comparison: thus, the figure has the deceptive appearance of a superabundant nutrition. This is a one-sided nutrition, the appropriation of fatty material to the neglect of the solid, motor machinery of brawn and muscles.

The mental traits seem to take direction and tone from the bodily characteristics. The passions move slowly and are easily kept under control, in marked contrast to those of the sanguine man who has no more control than is sufficient to keep him within the not too narrow limits of the social barriers. From the moderate emotional development there is little need of energetic will-power. Where the moral qualities have any chance of growth and exercise they are always "good people," orthodox, and conservative. The mind acts slowly, but is very retentive, logical and sound in its conclusions. They are persistent in their undertakings, honorable in their affairs with other men; commonplace and common-sense govern them in their daily life. They are apt to be dull companions, but constant and steadfast friends.

This temperament is found in its most perfect form among men; women rarely show it uncrossed, especially as it easily blends with other temperaments. There is no doubt but in this type there are inherent defects of histological structure. Dr. Southey says it is due to a too exuberant vegetative cell-life. Whatever may be the radical cause, persons of this type are weak in vital energy, and short-lived. They are the usual subjects of structural changes, such as scrofula, phthisis, and articular rheumatism, and in whom these morbid processes show the largest ratio of mortality. It will be noticed that these are diseases with a marked hereditary force. It would be interesting to study how much of this heredity exists in the morbid processes, or in the temperament itself, which offers a fair field for their onset.

Nature exerts herself in a more eccentric manner in the nervous temperament. Here we find greater variety in the physical signs, and diversity in the mental traits. Typical instances of the nervous temperament are not good specimens anatomically. In stature they are below the average, the bones small and lightly covered with flesh in both sexes up to middle life. The head is large and covered with not over-abundant dark-brown or black hair; the eyes are dark, the skin dark, sallow, and pale; pigmentation of the skin is more abundant than in any other temperament, while the cuticle is hot, dry, and firm. The muscles are small and compact. Persons of this temperament are capable of sudden outlays of great strength, but the muscles do not work in harmony, the movements being oftentimes irregular. The want of nervous coördination is a marked trait, and tells upon their efficiency in any occupation requiring trained and accurate touch. Dr. Southey explains this by what he calls cerebro-central preoccupation, which means that the brain and spinal cord are slow in receiving and responding to the wants of different and remote

parts of the body. This is further shown in the unequal distribution of the circulation, the head being often hot while the feet are cold, or the extremities are cold while the body maintains a nearly febrile temperature. The heart beats more rapidly than in other temperaments, or is attended with nervous irregularity in its action. Functionally the nervous temperament is liable to serious complications; the liver is one of the organs more liable to acute derangement—not, however, in the direction of over but rather that of under action. Digestion is a delicate function, the merest trifles interfering with its proper performance. A leading trait of the nervous temperament is the mutual reaction between it and the vital glandular functions; thus sudden mental or nervous impressions will upset the whole glandular machinery, or serious mental or nervous disturbances result from causes acting in the opposite direction.

If we were to select any one quality as the leading trait of the mental constitution of this type, it would be the great emotional tension. The emotions often usurp the place of higher faculties, and reason, judgment, and the sense of right or wrong, are biased or replaced by emotional qualities. They have an acute sense of right or wrong, but they are disposed to give it a personal rather than a vicarious application. They have an extraordinary capacity for both pleasure and misery, and the nervous man may be said to be undergoing one or the other through life, never knowing what it is to be in the happy mean of negation. They are never contented with their surroundings for any great length of time, but chafe and fret against their fate, no matter how happy it may seem. They have great fixity of opinion, and but little respect for that of others; and are prone to find a particular antagonism in persons of their own temperament. The sexual emotions are unduly developed, oftentimes giving tone to the character, or acting with explosive violence. Persons of this type are not among those who form the grand aggregate of the conservative opinion of society, the inflexible and implacable character of which we all know, and which upon the emotional tension of the nervous man often reacts harmfully rather than well. Typical instances of this temperament are confined to the male sex, the other sex usually showing a cross with the sanguine or bilious.

This temperament does not show a liability to any class of disease, but gives its own characteristic reaction upon the disease itself. From the ascendency of the nervous system in the physical and mental composition, diseases of the nerves are very liable to appear, but not as a primary derangement any more than as a complication grafted upon some previously-existing disease. Nervous headache, neuralgia, epilepsy, insomnia, and hysteria, are among the nervous affections most liable to appear, either as primary or secondary derangements. With this class it is difficult to give an opinion as to the result in any serious disease (prognosis), as they often die of diseases that in other

temperaments are deemed trifling; and then again, on the contrary, make most surprising recoveries. With them the will-power is oftentimes an element in the recovery, throwing off disease by the determination not to yield to its influence. There is no doubt but that this temperament is more liable to mental derangement than any other; the great emotional intensity and the difficulty of moral control laying the mind open to causes that tend to produce insanity. Many of the nervous constituents of this type belong to the bilious temperament. We have but to tone down the nervous excitability of the first by an addition of the phlegm of the lymphatic, and add flesh to the spare, nervous figure, and we have the bilious temperament. In its typical phase, the subject is apt to be grave, taciturn, even morose; mind and body move slowly but surely, not eccentrically, but by determination and conviction. Persons of this temperament are remarkable for inflexibility of will, sound judgment, strong convictions, abiding affections, and great love for those dependent upon them.

The study of the relations of temperaments to development and vitality is one of great interest. While we know tolerably well their reaction with disease, and the groups of diseases that are liable to cluster round them, we have but few facts bearing upon the normal relations of the temperaments to vital capacity. There are many difficulties in the way of this study. In the first place, we have no unit of measure or comparison, and, in the next, it is difficult to collect the facts. In a very remarkable work consisting mainly of tabulations of a vast number of data relating to anthropometry, or the measurement of men, I discovered facts that throw considerable light upon this subject. During the late war of the rebellion the provost-marshal-general had to pass upon the fitness for military service of a vast number of conscripts. The results of over a million examinations are embodied in two massive quartos, by Dr. J. H. Baxter, late chief medical officer of that bureau of the War Department.[1] From the elaborate statistical table of Dr. Baxter, I am able to construct a few tables that throw light upon some of the more obscure relations of temperaments. The facts embodied in the tables are picked out here and there from this mass of tabulation; while the figures have suffered no manipulation, except such as may be necessary to arrive at mean values.

A word as to the value of complexion as indicating temperament. A light color of the hair and skin, and blue or gray eyes, instead of indicating any one temperament, define broadly a group of two—the sanguine and lymphatic. A sallow or dark complexion, with black eyes and hair, indicates the bilious and nervous, and in this country, among natives, probably an excess of the latter. If, for the sake of narrowing the dark-haired group, we adopt the more modern classifi-

[1] "Statistics, Medical and Anthropological, of the Provost-Marshal-General's Bureau." By J. H. Baxter, A. M., M. D. Washington, D. C., 1875. Two vols., 4to.

cation, and ignore the bilious temperament, we have in this class only the nervous, while in the first group we have both the sanguine and lymphatic, with no means of separating them, except that the national characteristic shows an excess of the sanguine over the lymphatic, probably about the ratio of three to one.

TABLE II.—VITAL CAPACITY AS INDICATED BY RATIO OF CHEST-EXPANSION OF OVER THREE INCHES FOR ALL HEIGHTS TO COMPLEXION. Based upon the examination of 190,621 American-born white men accepted; expressed in ratios of 1,000.

| GIRTH OF CHEST AT EXPIRATION. | LIGHT.[1] | DARK.[2] |
|---|---|---|
| Under 29 inches | 3.588 | 1.141 |
| 29 and under 31 inches | 37.654 | 15.285 |
| 31 " " 33 " | 98.387 | 46.906 |
| 33 " " 35 " | 103.015 | 56.605 |
| 35 " " 37 " | 46.255 | 26.793 |
| 37 inches and over | 12.676 | 7.151 |
| Total number of men accepted | 126,445 | 64,176 |

Table II. shows the relation of chest-expansion to complexion. The range of chest-movement, while it cannot be deemed an absolute measure of vitality, which must be regarded rather as the sum of organic and functional action than the degree of perfection in any one set of organs, yet may be fairly assumed to bear a close relation to the general vigor of the system that defines the quality of vital activity. A free chest-expansion implies a large consumption of oxygen, a corresponding degree of force and activity in the circulation of the blood, and this, in its turn, calls for a large demand for food, with a proportional muscular vigor. In the table, a chest-expansion of over three inches is taken as the basis of comparison, for the reason that, at an expansion less than this, men of impaired strength may be included. It is but necessary to glance at the table in order to understand all that is implied by it—that size and muscular vigor of the sanguine and lymphatic greatly exceed these conditions in the nervous.

TABLE III.—RATIO OF DISEASES TO COMPLEXION.

| DISEASES IN GENERAL DIVISIONS. | Number examined, 117,029. DARK. Ratio per 1,000. | Number examined, 217,292. LIGHT. Ratio per 1,000. |
|---|---|---|
| General diseases | 26.857 | 31.552 |
| Diseases of the nervous system | 11.322 | 12.366 |
| Diseases of the circulatory system | 30.881 | 36.614 |
| Diseases of the respiratory system | 9.271 | 10.902 |
| Diseases of the digestive system | 87.978 | 95.894 |
| Diseases of the urinary system | 1.871 | 2.467 |
| Diseases of the generative system | 6.392 | 7.713 |
| Diseases of the organs of locomotion | 30.334 | 37.180 |
| Diseases of the cellular tissues[3] | 0.752 | 1.063 |
| Diseases of the cutaneous system | 11.638 | 11.860 |

[1] Blue or gray eyes; light hair. [2] Black or hazel eyes; dark hair.
[3] This division includes abscess and obesity only.

In Table III. we have the ratio of disease to complexion. In this, the light complexions show their marked predisposition to skin-diseases; and, notwithstanding their free lung-expansion, show a nearly equal liability to diseases of the respiratory organs with those of dark skins. The light men prove their greater glandular and muscular activity by their excess over dark in diseases of the digestive, circulatory, and locomotor systems; while the dark group, although composed largely of men of nervous temperament, nearly equal the light in frequency of nervous disease. It is interesting to note that, in the same table from which Table III. is compiled, Dr. Baxter gives the total of dark men rejected for all diseases at 38,916, and of the light, 83,700, a difference rather less than that indicated by the mean difference as exhibited in our table. In general diseases, which include fevers, infectious diseases, and all others not confined locally, we find the light men leading the dark by a difference only equaled by their excess over the latter in diseases of the digestive system. This is due, I think, in a great measure to the predisposition of the sanguine to diseases of the febrile or inflammatory type, as has been already mentioned.

TABLE IV.—Ratio of Deformities to Complexion.

| Deformities. | Number examined, 117,129. | Number examined, 217,321. |
|---|---|---|
| | Dark. | Light. |
| | Ratio per 1,000. | Ratio per 1,000. |
| Curvature of spine | 4.110 | 4.874 |
| Atrophy of limb | 3.640 | 4.303 |
| Club-foot | 1.128 | 1.579 |
| Wry-neck | 0.103 | 0.143 |
| Deficient size of chest | 11.100 | 17.405 |
| Deformity of chest | 2.128 | 2.996 |
| Loss of limb | 0.598 | 0.686 |
| Defects or deformities of hand | 7.032 | 7.699 |
| Defects or deformities of foot | 8.605 | 9.899 |

Table IV. gives an idea of the ratios of deformities in the two groups, and, while not proving much either way, presents a few facts of great interest. It will be observed that the physical defect which shows the greatest difference, and that in favor of the dark class, is deficient size of the chest. In view of the fact that light men exhibit a larger range of chest-expansion, this excess in the defective size of the chest is unlooked for. The other chest-defect is deformity, in which the difference in ratio in the two groups is only about .18. The fact that two classes are made in the chest-deformities leads me to suppose that the deformities are congenital, or the result of defective development in childhood; while the deficiency in size is the result of disease or injury later in life. This supposition opens the way to an explanation of the phenomenon. Owing to the greater liability of

the light, or partly sanguine group, to active inflammations, a potent factor in causing this deficient size of the chest is inflammation, mainly pleurisy and pneumonia, and, as a not uncommon result, a collapse of one, or both, of the chest-walls. This theory is the only one that offers a reasonable explanation of a very remarkable statistical result. The increased ratio in both groups, but notably in the light, of defects or deformities of the feet rather than of the hands, while having no relation to the difference of temperament, shows the careful way in which Nature protects the natural weapons of human beings—the hands. It confirms, in a broad way, what has probably been noticed by the observant reader, that deformities of the lower are more frequent than those of the upper extremities.

These few figures, taken from Dr. Baxter's vast collection of statistics, if not demonstrating anything positively, have at least the merit of not proving too much—a common fault of figures, if we are to believe the anti-statisticians. They are important, however, in showing the direction in which the study of temperaments may be pushed in order to give practical results. Social reformers, so called, human-science men, and less respectable students under various names, have used temperaments as their physiological basis for widely different theories. To one who is content with marriage as established by law, society, and religion, it is a suspicious circumstance that this is the social relation that has sustained the most determined assaults. The physiological attacks have been made in the interests of marriage-reform, "natural marriage," and of no marriage at all. While there is very strong evidence showing that intermarriage between relations tends to the deterioration of the offspring, there are hardly any facts showing that the matrimonial union of healthy persons of like temperaments has the same effect. It is true that social theorists assert the contrary, but they do so without considering that the intermarriage of kin, from which they draw their chief arguments, is surrounded by conditions that cannot exist in the intermarriage of like temperaments. That there are deep-lying physiological reasons against the union of relations, we need go no further than the oft-quoted fact of the sure impairment of the stock of domestic animals from inbreeding, to establish. Whatever the source of this gradual impairment may be, it is wanting in the marriage of those who are allied only by similarity of temperament. In the absence of conditions that are necessary to render the arguments drawn from analogy valid, the advocates of the theory of physiological incompatibility are obliged to fall back upon facts having a direct bearing, and they have in this field, as yet, reaped no harvest. There is, however, in the human family a sort of natural selection existing, that renders a marriage between parties of like temperament not an ordinary occurrence. Both Dr. Ryan and Mr. Walker, in their works on marriage, refer to

the common tendency of one sex to seek the opposite temperament in the other. But, upon the subject of matrimony, even in its physiological relations, society unwittingly does very well.

## THE ICE AGE.

By L. P. GRATACAP, Ph. B.

AT the end of that long course of geological ages, from the Archæan to the Tertiary, which built up the solid portions of the earth in their present configuration, geologists now universally recognize, in the evidence before them, the presence of a remarkable and stupendous period—a period so startling that it might justly be accepted with hesitation, were not the conception unavoidable before a series of facts as extraordinary as itself, and which, partaking of its astonishing character, are explained upon no simpler hypothesis. This era is known as the Glacial. It was an era which has left its traces in unmistakable monuments over the surface of either hemisphere, and written its history in no less explicit characters upon their rocks. It was an epoch of arctic rigidity, when the temperature of the earth had become so lowered that the cold regions of either pole *alternately* were permitted to extend their previously contracted circles over the temperate latitudes, and to envelop with a universal and prodigious mantle of ice the lands which once, beneath milder suns, had been the home of an abundant and tropical vegetation. The skirts of that glacial sea which perennially spreads its icy and resplendent surface over polar lands had then, by a favorable conjunction of solar and terrestrial influences, been expanded so widely, that to within the latitude of 39° north its frigid folds hid the surface of the earth, while below the equator a similar period seems to have left scarcely less visible traces amid the forests and pampas of South America. The evidence which has established the actual presence of these arctic conditions over a great portion of our earth is complete and irrefragable, and, aided by the contemporaneous study of Alpine glaciers and the Greenland icebergs, we can draw conclusions as to the nature and the succession of events which these conditions occasioned.

It was Agassiz who first insisted, perhaps almost with trepidation, that Central Europe, England, Scotland, and Ireland, had been buried beneath thousands of feet of solid ice; that from the mountain-tops of Scandinavia, the Grampians of Scotland, the Lake Hills of England, and the summits of the Alps, had proceeded vast rivers of ice whose confluent seas had swept over Europe, and beneath their resistless, ceaseless, and perpetual advance, grooved it with valleys, channeled the courses of its rivers, engraved its rocks, scooped out its lakes, and

scattered their burden of *débris* far and wide over its plains. The conception was a bold, almost a terrifying one; and, because the actual history and nature of glaciers was so little known, it was regarded with aversion and spoken of with contempt. Agassiz had laboriously studied the glaciers of the Alps, he had conned the lesson they taught with eager apprehension of its great significance, and he knew so well every characteristic of their work that he instantly recognized abroad the same indelible evidence of their past presence.

Venetz, Rendu, and Charpentier, had preceded him in glacial study, and had insisted upon an extension of the Alpine glaciers far beyond their present beds in past ages, but had not realized the immense utility of these views in explaining the glaciated surfaces of Europe. Forbes, Hopkins, and Tyndall, succeeded him in the investigation of glacial physics, and by their close scrutiny into the constitution of ice, and the laws of ice-making and glacial motion, fairly established a new department of physical science, and added confirmation to the views of Agassiz.

Now, let us examine some of these singular and hitherto inexplicable records, which elicited Agassiz's theory, and which, long before they were harmonized by that assumption, had been attentively examined by geologists and explained upon other grounds. Furthermore, we will review them without reference to the theory of glacial action, and only subsequently compare them with the effects now being produced wherever glaciers and icebergs are at work.

The rocks as they lie in place, the flanks and summits of mountains to heights of 5,000 and 10,000 feet, and the surfaces of outcropping masses over immense areas of the world, are all gauged in long, straight channels, sometimes a foot deep, sometimes eight feet deep, with widths from two to three feet. These grooves, of all dimensions, pass over the rock in groups like mouldings, and the rocks they occur upon are polished and oftentimes lustrous. The channels diminish in size to the faintest striæ, which, like sharp scratches, cover the surface, running along at times in parallel series, or diverging in different directions, as though the great primitive plane had varied its course over them, scouring with exquisite fineness.

These lines and runnels score the rocks over the Northern United States and Canada, throughout Europe, in Asia, and over the shores of South America. We discover almost instantly that in the same region they have the same direction; that they seem, as it were, to stream with us from the north; and that, wherever other scores contravene this, these secondary markings are themselves harmonious, indicating some subsequent action upon the rock, in character similar to the first, though varying in its motion, and probably restricted in its extent and importance. Thus the scores upon the rocks of New England point northwest and southeast, and only local derangements disturb this prevalent direction. The easting increases as we progress

to the ocean, reaching its maximum in Maine and the borders of Canada; while, as we retire from the margin of the States, we observe that the scratches and grooves acquire a north-and-south direction, becoming nearly meridional over New York, and then slowly swing round to the west, until in Ohio, Indiana, Illinois, Missouri, and the western limits of the continent, they lie pointing northeast and southwest. Thus they assume a rudely-outlined radiation from the highlands of Canada, and stretch out from an hypothetical centre there like the multiplied spokes of a great wheel. In Switzerland they sweep down and out from the central ranges of the Alps in all directions, and, while locally uniform, they converge from the south, and east, and north, and west, toward the lofty slopes and pinnacles of this congeries of mountains. Over West Russia and Northern Europe, where the markings are discovered, they indicate the Scandinavian mountains to have been the seat of whatever disturbance or agency has, at a distant period, fluted and engraved the continent; similarly, as the rocks lie related to the Highlands of Scotland, the Lake Hills of England, or the mountains of Wales, the striæ impressed upon them extend toward every point of the compass. They stream north and south from the summits of the Pyrenees, from the peaks of the Caucasus, and down the valleys of the Himalayas. It must be understood, however, that these conclusions are based upon an average of the bearings of the grooves in each instance, and that these are infinitely varied by the construction and irregularity of the land.

Thus over greater portions of the world we find the rocks furrowed, polished, and striated, in long, frequently deep and rectilinear grooves, which lie in groups and series identical in direction, and pointing to associated highlands, or distant continental mountain-ranges, as the source of whatever strange and inexorable instrumentalities have produced them. Over New York Island the gneissoid and granitic rocks, where they raise their tilted strata and broken shoulders above the ground, are scored frequently with deep and sinuous channels. In Central Park, along Fifty-ninth Street, up the west side, the contorted and twisted humps of gneiss are moulded in this way. Sometimes, where a rupture exists, and one part of an outcrop has fallen below the other, the grooves are continued on the lower half; frequently the lines are crowded together like rulings on a page, and again the groove is of irregular depth, its floor rising and falling as though hitches had occurred when it was first planed, the great chisel meeting resistance, or being thrown up at points along its path. In the White Mountains the sides of the mountains, the valleys, the top of Mount Washington, at 5,000 feet above the sea, are all cut with these strange furrows, the rocks polished, and the whole country bearing these evidences of past erosion wherever the naked rock meets the eye. Over Maine the same phenomena present themselves in endless succession, the grooves striping

the country, and losing themselves in the sea along the coast, while they corrugate the borders of the innumerable bays, and the walls of the deep fiords that indent the shores. These furrows can be traced for miles across the country, cutting the three ranges that lie between Bangor and the sea almost at right angles, traversing these highlands as though they were level surfaces, dipping beneath the sea, and reappearing upon the sides of Mount Desert, to be again lost in the waters of the Atlantic. Unquestionably, over that sea-floor, could we follow their tracks, the same furrows continue to the verge of the continent which lies miles out to seaward, when the steep edge of the land falls precipitately to the true bottom of the ocean. Over the West, throughout Canada, and upon the ancient rocks of the Great Lakes, these evidences of past erosion exist upon an enormous scale. As a rule, these striæ indicate a planing surface advancing from the north, and, though a second series may occur, as upon the islands of Lake Erie, from east to west, whose furrows obliterate the first inscription, such phenomena are local merely, and infrequent. Again, upon the Sierras, the tops and declivities of the ranges are scored and engraved with the indelible signatures of past erosions, and the rocks of the barren wastes of British America are signalized in the same manner. So much for striæ: we perceive their universal presence, and their marked reference to the north, or elevated regions which dominate over level plains.

The second feature of this epoch, designated by common consent the Drift, is a series of surprising facts, evincing, throughout all this deeply-scored and paneled country, the past presence of extraordinary transporting agencies. We find rocks of enormous size, in some instances weighing 3,000 tons, planted in fields and lowlands, or strewed over hills and moors, where no rocks lie in place, sunken in the soil where the lithology of the district is entirely distinct, while that of the monoliths themselves is identical with rock many miles northward. These gigantic bowlders, Titanic mementos of the past, are scattered over Central Europe, over Germany, Holland, and Russia, are identical in character, and can have no nearer origin than in the mountains of Scandinavia. Some of these blocks of stone are of incredible dimensions, and are accompanied by innumerable smaller ones that lie over these districts as if flung in sport by some pre-Adamite Antæus. They have served the most useful purposes in the flat countries through which they are found, being used for buildings of every description, and their smallest associates have helped to pave the highways between Hamburg, Magdeburg, and Breslau. Accredited in ruder times to the malevolent agency of man's spiritual foes, they were called *devil-stones;* but Science, recognizing their distant origin, has named them *erratics*, and the Germans, more picturesquely, *wanderers*. Not only are they found upon level and loamy lands, utterly unaccountable except by the assumptions of transpor-

tation, but they are also discovered capping the cliffs of mountain-chains, hanging by the side of depths, over which they must have been carried, and into which, by the Nemesis of destiny, they are now doomed to fall. The Jura Mountains, north of the great valley of Switzerland, and opposite the western or Bernese Alps, along the frontier of France, are thus studded with these bowlders, some of them containing 50,000 to 60,000 cubic feet of stone. These have come from the Alps; they are crystalline rocks, gneiss, and granite, and they lie upon ridges of limestone. They are virtually nothing less than dislocated fragments of those abraded and decreasing hills perched upon the Jura cliffs. Prof. Guyot has placed, beyond all doubt, their home upon the summits and sides of the Swiss Alps, and shown that they have attained their present eminence by a positive carriage from these original localities. This position has indeed been made impregnable by a protracted and laborious survey of innumerable "wanderers" found upon the Juras, whose lithological character identified them with the Alpine formation, while it served to trace the probable path of their transmission. These blocks have been found at elevations ranging from 2,000 to 3,500 feet above the sea, and in Carinthia similar erratics have been described at great elevations, proceeding from an opposite quarter of the Alps.

In North America, and especially throughout the Northern States, the bowlders are numerous, often of great size, and indicating transits of many miles. Over the Eastern, Middle, and Northwestern States, bowlders, that have emigrated from distant points to the northward, occur in such abundance that they may almost anywhere be found if the inquirer will only examine the country he passes over. Upon Mount Katahdin, in the Moosehead region of Maine, stones can be seen, lying over 4,000 feet above the sea, fossiliferous in their nature and coming from northern sites; while toward Mount Desert, masses, some forty to fifty feet in height, are sprinkled everywhere, and, as in the case of the Dedham granite distributed to the south, invariably show northern origin. In Berkshire County, Massachusetts, these traveled rocks lie in long alignments, passing over the Lenox Hills, and extending in a generally southeasterly direction for fifteen or twenty miles, and have been filched from the Canaan and Richmond Hills across the line in New York, being of chloritic slate, with angular specimens of limestone intermixed. Some granites from Vermont, on the west of the Green Mountains, have been lifted over these barriers and transferred to the southern margins of Massachusetts; while in Vermont a bowlder weighing over 3,400 tons, and known as the Green Mountain Giant, has been drifted from the Green Mountains easterly across the valley of the Deerfield River, and planted 500 feet above that stream. In Michigan, near the Menomonee River, a field upon the northern slope of a mountain is densely covered with bowlders, so that a mile can be traversed without once touching the

ground. Again, huge nuggets of copper, torn from the immense deposits of native copper at Keweenaw Point, Portage Lake, and the Ontonagon district, on the southern shore of Lake Superior, are found widely disseminated to the south of these localities in Michigan, Wisconsin, Ohio, and Minnesota, a few of which have weighed 300, 800, and one 3,000 pounds. From the sides of the White Mountains fragments of rock have been carried away, and not only conveyed southward, but, as Agassiz first pointed out, distributed northward, though only at comparatively slight distances. Long Island, that narrow fork of land running eastward and separated from the southern shore of Connecticut by the Long Island Sound, a shallow and turbulent trough, is lined, alike on its southern and northern edges, with bowlders, while its backbone of low hills is also strewed with their *débris*. They occur gathered together in groups forming topographical features in the landscape, and single ones have a weight of 2,000 tons. As regards their origin, they seem to have drifted from three localities, from the Helderberg Mountains in Central New York, from Manhattan Island, and from various points in Rhode Island, Connecticut, and Massachusetts. Those about the west end of the island may be traced to the Eastern States lying to the north, while many of the western visitors appear to have approached along the valley of the Hudson from the Highlands of New York. On Staten Island we may trace still farther the current of traveled rocks, and find both centres of emigration represented: the bowlders, now gray with lichens, half emerging from the soil, or deeply buried beneath gravel, clay, and sand, or else dispersed in colonies over the surface like pebbles on a board. Manhattan Island, along its southern shore, has been dotted with bowlders of serpentine, dragged from Hoboken, while gneiss and anthophyllite from the bed-rock of the island, limestone from Kingsbridge, and jasper from the Palisades, have likewise been sown across it, though before the restless advance of population they are fast disappearing. In Westchester, Putnam, and Orange Counties, along the banks of the Hudson, these bowlders, all indicating northern extraction, are repeatedly found, frequently at heights of 1,000 feet. These erratics have come from the Shawangunk Mountains, from Whitehall, Essex County, and from Potsdam; in short, they are witnesses of an invasion of northern material prevalent over the State. That these rocks belong northward is not difficult to prove. The reasoning is simply this: When anthophyllite, for instance, a rock unknown *in situ* to Long Island, appears there in broken and detached masses, we must conclude it belongs to the nearest deposits of the same rock, where it occurs in place, as upon Manhattan Island, and the hornblendic rock, the gneiss, trap, and iron-ore, similarly found on Long Island, we refer to those conspicuous and well-known localities in Connecticut and Rhode Island where exactly these rocks, identical in chemical composition, are quarried.

In the West the same tale is repeated. Throughout Ohio, bowlders are found which are composed of rock utterly foreign to their present surroundings; indeed, of material not known within the limits of the State. These are found perched over declivities, buried in the soil with their exposed edges showing above the surface, or else lying unencumbered in slight depressions of the ground. In Indiana, Michigan, Illinois, Wisconsin, etc., they are omnipresent, and the streets of Cincinnati are paved with the smaller specimens that crowd in exhaustless trains upon the footsteps of their larger companions. In short, we gather the irrefragable testimony, wherever we look for it, through our Northern States, through Europe and Asia, and even along the western coast of South America, that some immense force has been exerted in times past, not only to dislocate and shatter the rocky barriers which opposed it, but also to carry away the evidences of its ravages, and scatter them in its southward movement far removed from their place of origin. Further, let it be remarked that, though one class of these erratics is composed of angular and unworn stones, another yields bowlders that have undergone severe attrition, and along their larger axes are striated and polished; bearing in mind, moreover, that the direction of their transit coincides with that of the furrows and flutings in the same region, we may strictly conclude that they are a feature also of the same excessive and gigantic system of erosion.

But there is another appearance which we believe vitally connected with these, and one of a yet broader and more significant character in its general relations than they are. Over Scotland, England, Ireland, Scandinavia, Denmark, Central Europe, Switzerland, Russia, France, Spain, and in North and South America, in short, wherever we discover bowlders and grooved surfaces, we find a deep and characteristic deposit, not the work of alluvial formations or recent detritus, for it underlies these, but the record of a vast disintegration which, having planed and corroded the continents, has covered the land with sheets of gravel, clay, silt, and sand, all intermixed with stones and bowlders, variously combined in their order of succession, and ranging in depth to over 300 feet. These immense beds furnish gravel for roads and ballast, sand for glass-making and mortars, and clay for pottery; their included stones and fragments are scored and embroidered with fine and interlacing striæ, and they cover the furrowed surfaces of either hemisphere for miles.

They represent the accumulated wear and tear of continents, under some extraordinary agent of erosion and denudation, whose teeth have resistlessly ground upon the solid rocks of the hills and highlands, hiding disfigured surfaces beneath a covering of ruin. Long Island is itself but one long dirt-heap: an accumulated pile of continental *débris*, sand, clay, gravel, intermixed and overlaid by bowlders, is here gathered together into a more or less stratified state,

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as if, in an enormous denudation of New England, the aggregated material, scoured from its hills and valleys, had been dropped just upon their outskirts in this long detrital barrow or mound. Yet over New England this same deposit is wide-spread; it lies up and down the valleys, it forms the terraces of its rivers, the shores of its lakes, and, spread over the face of the land, is frequently the immediate soil beneath the feet. This member of the geological series, exhibiting various phases in its deposition, from the bowlder-clay to the lake-ridges, is widely distributed, indeed is universal over the Northern States, and as far south as 40° north latitude extends its sheets and centres of pebbly and sandy deposit in mounds and ridges, themselves capped with accidental bowlders, and resting upon the furrowed and seamed surfaces of the rock beneath. Sometimes they may be found collected in heaps and walls at the foot of the polished rocks, as if silent and incontrovertible witnesses of their severe and prolonged erosion.

In Scotland it is the *till*, a stiff clay interspersed with polished stones, crowding down the valleys and prevalent over the lower slopes, varying in its lithological character with the character of the surrounding rocks. Gravel and sand beds are intercalated with it and superimposed upon it. In England, Ireland, Scandinavia, Switzerland, we discover identical strata—strata which, while yielding different subdivisions, in their entire extent are the same thing, and only varied according to the local force and extent of the wearing agent, the local peculiarities of the country over which it operated, and the effect which submergence beneath the sea had in redistributing and rearranging the beds of detritus already laid down. In the sequel we shall more particularly revert to this drift-material, and indicate the part it has played in the economy of our landscape-changes; how it constitutes the terraces of our rivers and the successive beaches of our Great Lakes, and how it has choked up the former courses of rivers, forcing them to find new ones by larger and circuitous deflections. Associated with this phenomenon are the appearances known as crushed ledges and *roches moutonnées*, both of which testify to the exertion of enormous pressure—the one of pressure continuous and progressive, the other, perhaps, of percussive and intermittent attacks.

*Crushed ledges* designate those plicated, overthrown, or curved exposures where parallel laminæ of rocks, as talcose schist, usually vertical, are bent and fractured as if by a maul-like force battering on them from above. The strata are oftentimes tumbled over upon a cliff-side like a row of books, and rest upon heaps of fragments broken away by the strain upon the bottom layers, or crushed off from their exposed surfaces. *Roches moutonnées* are those rounded and swelling prominences, often seen in a landscape, which, when examined more closely, show themselves to be truncated masses of rock whose asperi-

ties have been smoothed away by the same agency which has planed the rocks everywhere. Only the *roches moutonnées* have been left furrowed and scratched upon one side, whence the abrading and engraving tool advanced, but upon the other unscored, and hidden beneath a tail of fragments ground from their opposite slopes. The significance of this we shall see later.

Thus, imperfectly described, we have reviewed the most prominent features of a comparatively modern period, viz., the widely-grooved and polished condition of northern rocks, especially hard-grained rocks, which retain these impressions; the occurrence of wandering bowlders, transported longer or shorter distances from their primitive sites, and the detrital matter from continental abrasion deeply burying the rocky face of the country, and in ridges, mounds, and sheets, extending east and west, and along the greater water-courses, stretching itself down into the Southern States in irregular tails and projections. We will now venture to examine the theories advanced to explain these singular phenomena, and describe that one which best accounts for these facts, with many correlated ones, offering an hypothesis which rationally secures their complete and harmonious agreement.

## TEACHINGS OF A DAY.

By LOUISA S. BEVINGTON.

### MORNING.

WHAT'S the text to-day for reading
Nature and its being by?
There is effort all the morning
Through the windy sea and sky.

All, intent in earnest grapple,
That the All may let it be:
Force, in unity, at variance
With its own diversity.

Force, prevailing unto action:
Force, persistent to restrain:
In a twofold, one-souled wrestle,
Forging Being's freedom-chain.

Frolic! say you—when the billow
Tosses back a mane of spray?
No; but haste of earnest effort;
Nature works in guise of play.

Till the balance shall be even
  Swings the to and fro of strife;
Till an awful equilibrium
  Stills it, beats the Heart of Life.

What's the text to-day for reading
  Nature and its being by?
Effort, effort all the morning,
  Through the sea and windy sky.

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### AFTERNOON.

Purple headland over yonder,
  Fleecy, sun-extinguished moon,
I am here alone, and ponder
  On the theme of Afternoon.

Past has made a groove for Present,
  And what fits it *is:* no more.
Waves before the wind are weighty;
  Strongest sea-beats shape the shore.

Just what is is just what can be,
  And the Possible is free;
'Tis by being, not by effort,
  That the firm cliff juts to sea.

With an uncontentious calmness
  Drifts the Fact before the "Law;"
So we name the ordered sequence
  We, remembering, foresaw.

And a law is mere procession
  Of the forcible and fit;
Calm of uncontested Being,
  And our thought that comes of it.

In the mellow shining daylight
  Lies the Afternoon at ease,
Little willing ripples answer
  To a drift of casual breeze.

Purple headland to the westward!
  Ebbing tide and fleecy moon!
In the "line of least resistance"
  Flows the life of Afternoon.

### TWILIGHT.

Gray the sky, and growing dimmer,
  And the twilight lulls the sea;
Half in vagueness, half in glimmer,
  Nature shrouds her mystery.

What have all the hours been spent for?
  Why the on and on of things?
Why eternity's procession
  Of the days and evenings?

Hours of sunshine, hours of gloaming,
  Wing their unexplaining flight,
With a measured punctuation
  Of unconsciousness, at night.

Just at sunset was translucence,
  When the west was all aflame;
So I asked the sea a question,
  And an answer nearly came.

Is there nothing but Occurrence?
  Though each detail seem an Act,
Is that whole we deem so pregnant,
  But unemphasizèd Fact?

Or, when dusk is in the hollows
  Of the hill-side and the wave,
Are things just so much in earnest
  That they cannot but be grave?

Nay, the lesson of the Twilight
  Is as simple as 'tis deep;
Acquiescence, acquiescence,
  And the coming on of sleep.

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### MIDNIGHT.

There are sea and sky about me,
  And yet nothing sense can mark;
For a mist fills all the midnight,
  Adding blindness to its dark.

There is not the faintest echo
  From the life of yesterday:
Not the vaguest stir foretelling
  Of a morrow on the way.

'Tis negation's hour of triumph,
In the absence of the sun;
'Tis the hour of endings, finished,
Of beginnings unbegun.

Yet the voice of awful silence
Bids my waiting spirit hark;
There is action in the stillness,
There is progress in the dark.

In the drift of things and forces,
Comes the better from the worse,
Swings the whole of Nature upward,
Wakes, and thinks—a universe.

There will be *more* life to-morrow,
And of life, more life that *knows;*
Though the sum of Force be constant,
Yet the Living ever grows.

So we sing of Evolution,
And step strongly on our ways,
And we live through nights in patience,
And we learn the worth of days.

In the silence of murk midnight
Is revealed to me this thing:
Nothing hinders, all enables
Nature's vast awakening.

## HISTORY OF THE DYNAMICAL THEORY OF HEAT.[1]

By PORTER POINIER.

II.

ABOUT one year after the reading of the famous paper of Rumford, in the early part of 1799, Sir Humphry Davy, then but twenty years of age, published his first scientific memoir, entitled "An Essay on Heat, Light, and the Combinations of Light." Clearly enunciating the two systems of hypothesis previously held, he chose to follow Newton in rejecting the materiality of heat, while still clinging to the corpuscular or emission theory of light.

His position with respect to the existence of caloric he asserted in this thesis:

"THE PHENOMENA OF REPULSION ARE NOT DEPENDENT ON A PECULIAR ELASTIC FLUID FOR THEIR EXISTENCE, OR CALORIC DOES NOT EXIST;"

[1] Introduction to an unpublished work on Thermo-Dynamics.

proceeding to maintain it by a series of experimental *reductio ad absurdum*.

Premising that the temperature of a body could not be increased unless either its "capacity" were diminished from some cause, or heat were added to it from still other bodies *in contact*, and observing a production of heat to be consequent on friction or percussion, he enumerated the following as including all possible explanations of the phenomenon consistent with the assumption of caloric:

First, the production by the friction of a specific diminution in the "capacity" of the body, whereby caloric would be disengaged, and thus made sensible. This was the supposition which Count Rumford showed to be quite incompatible with the inexhaustibility of the supply.

Second, the liberation of caloric during some slow process of combustion accompanying the friction, the source in this case being the oxygen of the surrounding medium. This contingency was likewise anticipated by Rumford, who failed to detect any indications of such an action.

And, third, the production of some occult change in the bodies rubbed, whereby they might acquire the property of abstracting an unusual quantity of heat-substance from surrounding matter.

His argument against the existence of caloric depended, therefore, upon showing that these different suppositions were all contrary to the indications of experiment, whence the inference as to the untenability of the hypothesis itself. But, although this method of reasoning has been characterized as "somewhat confused," the following experiments upon which it was based are now considered classical.

Two parallelopipedons of ice, initially at a temperature of 29° Fahr., were fastened in an apparatus by which they might be rubbed together, and kept in a continued and violent friction with each other. They thus were almost wholly melted, the temperature of the resulting water being "ascertained to be 35°, after remaining in an atmosphere of a lower temperature for some minutes." The fusion also was observed to take place only at the rubbing surface.

From this experiment it was therefore to be inferred that the "capacity" of a body was not necessarily diminished by friction; for, according to the discoveries of Black, the melting of a quantity of ice could only take place with the absorption of a definite quantity of heat—its latent heat of fusion.

Upon the second supposition, Davy remarked:

"From this experiment it is likewise evident that the increase of temperature consequent on friction cannot arise from the decomposition of the oxygen gas in contact, for ice has no attraction for oxygen. Since the increase of temperature consequent on friction cannot arise from the diminution of capacity or oxidation of the acting bodies, the only remaining supposition is, that it arises from an absolute quantity of heat added to them, which heat must be attracted from the bodies in contact. Then friction must induce some change in bodies enabling them to attract heat from the bodies in contact."

To determine, therefore, upon this last alternative, he performed the following experiment:

A block of ice, having a small channel cut around its upper edge, was placed under the receiver of an air-pump. The channel was filled with water, and upon the block, though not in contact with the water, was also placed a clock-work so contrived that one of the external wheels of its machinery came in contact with a thin metal plate. By the friction between these surfaces a considerable amount of heat could be produced, which might be made to melt wax, tallow, or any similar substance fusible at the temperature which could be thus produced.

The receiver, previously filled with carbonic-acid gas, was next exhausted as completely as possible by the air-pump and absorption by caustic potash; upon then setting the machine to work the wax was melted rapidly, and the temperature of the whole apparatus increased by more than 1° Fahr., thus proving the excitation of heat under the conditions imposed.

Consistently with the remaining supposition—the third—it was then only to be inferred that caloric had been collected from the bodies in contact. Neglecting, however, the vapor of water which formed the rarefied atmosphere within the receiver, the only other body in contact with the apparatus was the ice. But against the assumption of this latter having furnished any heat, Davy here drew attention to the water still remaining liquid in the canal, and which presumably would have been frozen had the ice parted with any heat.

It is easy to perceive that such a course of reasoning was neither exhaustive with respect to the non-existence of caloric, nor conclusive as to the dynamic character of heat. For, had he even been successful in demolishing the doctrine of caloric, the simple refutation of one physical hypothesis could never have been construed into more than an increase in probability of all those opposed to it; and in this instance, perhaps no considerations would have been accepted as conclusive by the materialists, which, failing to experimentally establish the true nature of heat, should still have left their favorite notion open to any modification, however artificial, which might reconcile it in the least degree with facts which would be doubted and distorted in the interest of these preconceived opinions.

Heat being only a particular phase of energy, it was necessary and sufficient to show, as done by Rumford, with respect to its frictional excitation, that its production depended only on the expenditure of energy—implied in its inexhaustibility—and always in the same degree, as he proved by special determinations.[1] It was the subsequent

[1] Professors Tait and Balfour Stewart are authority for the statement that "Rumford pointed out other methods to be employed in determining the amount of heat produced by the expenditure of mechanical power, instancing particularly the agitation of water or other liquids, as in churning."—(Tait's "Historical Sketch," p. 7; Stewart's "Elementary Treatise on Heat," p. 307.)

extension of this experimental process to all modes of heat-production that constituted the great work of Joule, to be described hereafter.

But if Davy thus failed to render his experiments truly conclusive against the materiality of heat, his subsequent observations showed that individually his perceptions were most clear and definite.

Heat, ultimately, he conceived to depend upon molecular motion —calling this the repulsive motion—and to produce an effect exactly opposite to that of cohesion. The action of this motion in altering the state of aggregation, he interpreted essentially as is the custom now, and spoke of temperatures as indicating the relative quantities of repulsive motion in the same substance. He also mentioned three modes in which this motion might be increased:

"1. By the transmutation of mechanical into repulsive motion, that is, by friction or percussion. In this case the mechanical motion lost by the masses of matter in friction is the repulsive motion gained by their corpuscles.

"2. By the motion of chemical combinations of decomposition.

"3. From the communicated repulsive motion of bodies in apparent contact, that is, by conduction simply. And subsequently he generalized this statement in the dictum:[1]

"The immediate cause of the phenomena of heat, then, as Lavoisier long ago stated, is motion, and the laws of its communication are precisely the same as the laws of the communication of motion."

These essays of Rumford and Davy failed to produce, with a few rare exceptions, any perceptible effect upon the scientific opinions of their contemporaries. There would seem to have prevailed at this time a remarkable incapacity to appreciate the importance of experiments whose indications were opposed to preconceived ideas, and an antipathy to engage in unfamiliar issues; and the same distrust and indifference which so deadened the brilliance of Fresnel's immortal work in France proved quite effectual in deferring for the time the discoveries which might otherwise have followed the immediate development and experimental prosecution of this theory. Whatever interest was awakened seems to have been, for the most part, displayed in the petty, irrelevant objections, and misstatements even, brought against their methods of experiment and observed results; and the injustice of which, when not apparent, might have been easily exposed by a careful repetition or extension of these same determinations.

Dr. Thomas Young, however, in his "Lectures on Natural Philosophy," delivered at the Royal Institution, and published in 1807,[2]

[1] "Elements of Chemical Philosophy," 1812. Complete Works, vol. iv., p. 66. The laws of motion here referred to were those of Newton, especially the third, application to molecular magnitudes being included, and the modifications introduced by the new facts as to the effect of friction understood; for, "in Newton's day, and long afterward, it was supposed that work was *absolutely lost* by friction."—(Thomson and Tait, "Natural Philosophy," p. 108.)

[2] "Lectures on Natural Philosophy," vol. i., p. 653, *et seq.*

assigned to them their true significance, and, reviewing much after Bacon the existing state of experience upon the question, drew forcibly attention to the superficiality of the views of those who still adopted the hypothesis of caloric.

In 1810 Haldat performed an extended series of experiments upon the heat produced by friction between various metallic surfaces.[1] The results which he obtained were not, however, decidedly confirmatory of either supposition, but especially serve to increase our admiration for the acumen of Rumford in perceiving and stating the true law of its excitation.

The rubbing surfaces employed by him were similar in size and shape; the pressure between them was maintained nearly constant in several different experiments; but the power or energy was received in measured quantities, and from an indefinite source, namely, the pulley of a turning-lathe.

The quantities of heat developed for the same number of revolutions, or in proportionate times, were naturally, therefore, different for different metals; but as to the cause of this diversity he hazarded no positive opinion, and indeed his recorded observations do not seem susceptible of reduction to any particular theory. Had he measured the energy absorbed, or the coefficient of friction between the rubbing surfaces, he might possibly have been able to trace some relation between them and the heat produced in the operation. As it was, his observations as to difference of capacity, the influence of density, etc., were equally confused with the results, which he obtained on varying the pressure and substituting different metals; and although upon the whole his conclusions were adverse to the calorists, they were not definite enough to attract any notable attention.

In tracing thus far the inception of mechanical-heat theory, we have seen two important generalizations made: The one, fully attested by experiment, referring to the transformation of work into heat in a peculiar class of operations, and entirely independent of hypothesis, namely, that "the heat generated by friction is exactly proportional to the force with which the two surfaces are pressed together, and to the rapidity of the friction." The other, more comprehensive, including in the spirit of its enunciation thermal phenomena of every variety, and to a greater or less extent dependent on molecular and other hypothesis. These early statements are quite characteristic of, and may be used to illustrate, a subsequent division of our subject necessitated by experimental difficulties of investigation and verification.

The proposition that the entire energy existing in the universe is a magnitude as definite and unchangeable as the quantity of matter which it contains, is now considered one of the most fundamental and far-reaching in natural philosophy. The experimental evidence pos-

[1] *Journal de Physique*, vol. lxv., p. 213; *Nicholson's Journal*, vol. xxvi., p. 30.

sessed as to the fact appears for the most part in the invariability of the ratio of any dynamic magnitude of a definite kind which disappears to that of another kind which is thereby produced, and the numerical value of which, for a particular transformation, depends only on the relative magnitude of the characteristic units as compared by the same standard system of dynamic units. That is, that the conversion of one manifestation of energy into another takes place with as great certainty and absence of waste, and with the same integrity of the elementary magnitude, as the more formal conversion of foot-pounds into kilogrammetres, or British thermal units into calorics. To the experimental establishment of this principle as involved in transformations between heat and work, and which is called the First Fundamental Law of Thermo-Dynamics, we shall return hereafter.

But in the transformation of heat into mechanical effect or work, an additional principle has been found to hold, respecting the transformable quantities of these two magnitudes as influenced by temperature, and which is known in like manner as the Second Fundamental Law of Thermo-Dynamics.

Experience has not as yet encountered any phenomena at variance with these fundamental laws; which furthermore agree with the strictest requirements of intuitive science, and illustrate, respectively, the axioms that nothing is by natural means creatable from nothing, and that things are equal to the same thing only which are equal to each other. In the development of these two principles, and the application to them of empirical laws with reference to the behavior of bodies under the action of heat or mechanical effect, consists the first principal division of the subject in which the results obtained are generally reliable.

But in assuming a complete analogy between molecular and mass energy, and in tracing the consequence of this assumption through the different forms of material aggregation, the conclusions reached are generally much beyond the present power of experimental science to explicitly confirm, and, although many of the results obtained in these investigations are of great probability, they yet are of inferior certainty to those properly included in the first division.

In short, although the laws which govern the relations of molar energy to heat are in the abstract positively known, yet in endeavoring to trace the distribution and precise condition of energy when it becomes absorbed within a body, or *vice versa*, the mode and minutest detail of its transformation into gross mechanical effect, the most consistent theories have heretofore depended on the hypothesis that actual or real heat is a condition of molecular kinetic energy, and that the various latent heats are due to potentialities of molecular arrangement.

The full extent to which this principle of the indestructibility of

energy had previously been recognized, or involved in the dispute as to the intimate constitution of heat, may be inferred from what has been already given of the history of heat theory. But in 1822, M. A. Seguin, in a letter to Sir J. F. W. Herschel,[1] explicitly asserted it in support of the dynamical existence of heat, and in explanation of the work obtained from caloric in the steam-engine. The view of the subject he claimed to have derived, some years before, from his uncle, the celebrated Montgolfier.

Soon after he restated these considerations in a letter to Sir David Brewster,[2] wherein, by a perfectly legitimate course of reasoning, and in a very lucid manner, he showed that the accepted teachings of the calorists led to a violation of this principle of the conservation of energy. For, quoting his own language:

"If we suppose, indeed, that at each stroke of the piston of a high-pressure steam-engine the quantity of caloric employed is represented exactly by the elevation of temperature of the water of condensation, abstracting all loss, it follows that we have lost nothing in obtaining a very great effect, and that, if it were possible (which is supposable)[3] to condense the caloric contained in a mass $M$ into another represented by $\frac{M}{x}$, in such a manner that it may be reduced into vapor at the primitive pressure, we may, by means of a small quantity of caloric, produce an indefinite number of oscillations."

He expressly stated, therefore, that after a mechanical effect had been produced through any given thermal agency, as in a steam-engine, only that quantity of molecular motion or heat which had not been thus appropriated would remain as heat.

To him, therefore, most undeniably belongs the credit of having first publicly urged the principle of the conservation of energy against the materiality of heat, and of having considered in this connection the reverse phenomenon of the performance of work by thermal agencies.

The only indefinite or erroneous particular in his statement was that arising from the rather incautious introduction of molecular hypothesis. His leading argument was thoroughly scientific, but the oversight or neglect to refer explicitly to the disturbing effect which latent as distinguished from sensible heat might exert upon the experimental verification of his principles, served afterward as a point of attack upon the accuracy of his reasoning in general, and an opportunity, abundantly improved, to detract from his true merit as an early supporter of the mechanical theory of heat.

This criticism depends upon and applies with still greater justice

[1] Published in the *Edinburgh Philosophical Journal*, x., p. 280.

[2] Published in the *Edinburgh Journal of Science*, iii., p. 276, 1825.

[3] A particular instance of this supposition will be seen in our account of Carnot's engine.

to a principle which he subsequently enunciated in a work on railways,[1] in treating of the motive-power of heat, namely:

"La force mécanique qu'apparaît pendent l'abaissement de température d'un gas, comme de tout autre corps qui se dilate, est la mesure et la représentation de cette diminution de chaleur."

If in the single term "chaleur" Seguin intended to include both sensible and latent heat, his principle was undoubtedly correct; but it is to be inferred from an indicated method of determining the relative dynamical value of heat and mechanical units,[2] that he had quite neglected to take into account any change of molecular energy other than that of sensible heat.

Nearly identical with these, though much more celebrated, were the subsequent speculations of Dr. J. R. Mayer upon this subject. In a memoir published in Liebig's *Annalen*, for May, 1842, entitled "Bemerkungen über die Kräfte der neubelebten Natur," he undertook to answer the questions: "What are we to understand by force? and how are different forces related to each other?" Toward the latter part of the disquisition he entered upon the subject of the mutual convertibility of heat and mechanical energy, considering the generation of heat by the shock or gradual stopping of a falling body, by friction, and by compression; and illustrating by the heat excited in the bearings and rubbing surfaces of water-mills and railway-trains; and by the diminution of the earth's bulk in the falling of a body to the ground.

In this he first expressly used the term equivalent, in speaking of the relation of heat, to mechanical effect; and by the same method as that employed in the deduction of Seguin's value, though with more accurate data, found the distance through which any mass of water would have to fall, in order that its temperature, by the shock of sudden stoppage, might be raised from 0° to 1° Cent., to be 365 metres.

The physical reasoning upon which he founded this determination was manifestly incomplete, if not erroneous; and, on this account, his claims as an original promoter of correct theory have been made of late the subject of considerable dispute. In view of the historical importance attaching to this point, and because an allowable explanation of the phenomenon referred to will illustrate very fully the received distinction between sensible and latent heat, we here make a slight digression to consider more particularly the thermal effect attending the compression of elastic fluids.

The term *specific heat* is ordinarily employed to designate that quantity which it is necessary to impart to unity of weight of any

[1] Entitled "Études sur l'Influence des Chemins de Fer," p. 378, *et seq.* Paris, 1838.

[2] The method indicated, with the data then at his command, for steam, gave 650 kilogrammetres as the mechanical value of an increase of temperature of 1° Cent. in one kilogramme of water.

specified substance, in order that its temperature may be raised by one degree; no discontinuous change of physical state occurring. A part of this heat, it is thought, is used in raising the temperature of the substance, and thus increasing the *real heat* or thermal contrast of the body; while the remainder is expended in producing, as it were, some change in the potentiality of intermolecular distance, or molecular motions, not indicated by the thermometer, but in general attended by the expansion or contraction of the body heated. The energy existing in this latter form, and measured in heat-units, has been called by Clausius the ergonal content of the body.

If we were, therefore, to suppose the following effects produced, in a specified manner, during the reception of a quantity of heat by any portion of an elastic fluid, namely, an increase of temperature, a change in the mean distance or motions of the molecules not causing any variation of temperature and a performance of external work by the consequent increase of volume against exterior resistance, it is evident that we could not consider any one of these effects to be the dynamical equivalent of the whole acquisition of heat. Much criticism upon the original reasoning of Mayer has therefore been called forth by this fact, that, without proving the absence of the second effect above mentioned, or in any way referring to the possibility of its disturbing influence upon the calculation, he arbitrarily assumed that the mechanical energy expended in compressing atmospheric air should be regarded as the mechanical equivalent of the heat thus rendered sensible.[1]

But though erroneous in principle, this method of determining the mechanical equivalent of heat was afterward shown by Joule to involve no sensible inaccuracy of result in the case of air and other permanent gases.[2]

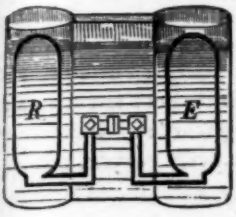
The experiment by which this conclusion was attained consisted in the repetition, with a slight but very important modification, of one originally designed by Gay-Lussac to investigate the effect upon the temperature of a gas of its free expansion into a vacuum.

The apparatus consisted of two reservoirs, $R$ and $E$, which might be joined by connecting-tubes and a coupling-nut, and each closed independently by a very perfect stopcock. Into one of these

[1] Besides, the analogy which he drew between the heat produced upon the sudden stoppage of a falling body, constituting a diminution of the earth's bulk, and the forcible compression of an elastic body, is by no means an admissible one, and in seeking to justify this view by the following statement: "Yet just as little as it may be inferred from the relations of falling force to motion, that falling force is motion, so little is the conclusion admissible in the case of heat" (that heat is motion). "We much prefer to adopt the opposite conclusion, that in order to become heat, the motion—either simple or vibratory, as light, radiant heat, etc.—must cease to exist as motion"—he succeeded only in rendering the subject more indefinite and confused.

[2] "On the Changes of Temperature produced by the Rarefaction and Condensation of Air."—(*Philosophical Magazine*, 1845, (3) xxxi., p. 376.)

dry atmospheric air was forced until a tension of about twenty-two atmospheres at the ordinary temperature of the room was attained. The other was exhausted by an air-pump. Being then coupled together, they were immersed in a tank containing about sixteen and a half pounds of water, which was stirred, and its temperature taken on a very sensible thermometer, indicating approximately thousandths of a degree. The stopcocks were next opened and the air allowed to rush from one reservoir to the other until the tensions were more nearly or quite equal in both. Lastly, the water was again stirred and its temperature carefully noted. A correction was obtained after each experiment, by noting the increase of temperature caused by an equal amount of stirring, uninfluenced by any possible effects of the expansion.




Five experiments upon the thermal effect thus attending the expansion of atmospheric air showed a mean increase in the temperature of the water of 0.0074°, while the correction to be applied amounted to 0.0068, leaving a difference quite within the limits of observation by this method. Joule, therefore, concluded that "*no change of temperature occurs when air is allowed to expand in such a manner as not to develop mechanical power.*"

If this result or property of atmospheric air had been known to Mayer, and construed by him to imply the total absence of a transformable, internal store of potential energy in gaseous substance, so that the energy embodying the condition variously styled its pure, real, actual, or sensible heat could only be affected by some external agency, mechanical or thermal, and if the effect upon a thermometer, produced by this condition, had been also known to vary directly with the whole quantity of energy comprising it, the method which he indicated would have led to an admissible result.

But, in reality, Gay-Lussac, from his original experiments, had not come to any very definite conclusions on this point. The temperature of each receiver had been found by him to change; but not using an equivalent device to that of the submerging tank of water, he had not been able to determine, on the whole, whether heat had been lost, or gained, in the expansion. When, therefore, Mayer, in 1849, defended his claims by a reference to these first experiments on this point, the answer was available to Joule that, prior to his own researches, the all-important principle assumed had not been recognized in science; and that the results obtained by Gay-Lussac tended only to render the question still more doubtful.

# STYLE.

By T. H. WRIGHT.

A RECENT historian of Rome, toward the close of his famous attempt to undeceive the world at large with respect to the genius of Cicero, sums up his argument in the following words: "Ciceronianism is a problem which, in fact, cannot be properly solved, but can only be resolved into that greater mystery of human nature—language, and the effect of language on the mind."

These words are suggestive—suggestive, too, of a wider question than at first sight appears. That men are influenced by language at least as much as by ideas; that power of expression is intimately associated with mental grasp generally; even that a fascination is exercised by style to which nothing equivalent is found in the accompanying thought—these are acknowledged truths, readily granted. But it is a most singular thing that they are so readily granted; it is singular that the question is not oftener asked, "Why is this so?"

How is it that language, which is but the vehicle of thought, comes to have a force which is not the mere weight of that which it carries? Even where this is not the case, where there is an equivalence of value in both style and ideas, great conceptions being nobly expressed, how is it that the matter and the form seem to have independent claims upon the attention? In a word, what is that in language which is not mere *expressiveness* of the obvious intentions of the writer, but is yet a merit?

At first sight there appears to be a simple answer to the question. Any of the numerous treatises on style or rhetoric abound with rules for the embellishment of discourse: the reader learns the importance of a choice of fitting words, of the judicious use of figures of speech, of the effect of melodious sentences and suitable cadences; he is instructed in the manipulation of complex constructions, and discovers the force of the gradation, the antithesis and the climax; in short, he is easily led to the conclusion that, besides *expressiveness*, language may have the merit of *beauty*.

That this distinction is a superficial one has been shown with great ability in an article by Mr. Herbert Spencer, on the "Philosophy of Style."[1] He there traces all excellence of composition to two principles—Economy of the Attention, and Economy of the Sensibility of the recipient. Assuming that a reader can have at his command only a definite amount of power of attention, it is clear that whatever part of this is employed on the form of a composition must be subtracted, and leave so much the less to be occupied in the matter. In its popular aspect this is a truth familiar to all. If any author is said

[1] Published in separate form, with flexible covers, by D. Appleton & Co.

to have an obscure style, it is meant that his form obstructs his matter; that it absorbs an inordinate amount of the reader's attention. If he is tedious, it is because his language, by its monotony or redundancy, exhausts our energies, and leaves us correspondingly deficient in the mental vigor to be devoted to what he has to say.

But Mr. Spencer pushes his theory yet further. He shows, with great ingenuity, how various ornaments of style, at first sight most remote from mere utility, are in reality but devices of language which subserve the same purpose of economizing attention. Thus the canon which prefers words of Saxon to words of Latin origin, is justified by the greater familiarity of the former, recalling the associations of childhood, and their comparative brevity, which adds to their force what it diminishes from the effort required to recognize them. On the other hand, the occasional effect of polysyllabic words is attributed to their associated significance; for the effort involved in deciphering or using them, by hinting at a corresponding weightiness in the things implied, gives a force to an epithet which may do for a sentence. The same principle which explains the rules for choice of words is also found adequate to the solution of the reasons why some one order of words is more effective than another; why certain sequences of sentences are better than others; what are the respective merits of the direct and indirect style, and so forth. Then follows an analysis of the various figures of speech—metaphor, simile, and the like—in which their amenableness to the same law is established; and, finally, the applicability of the theory, even to the complex imagery of the poet, is exhibited in a passage which it would be an injustice to the writer not to quote at length:

"Passing on to a more complex application of the doctrine with which we set out, it must now be remarked that not only in the structure of sentences, and the use of figures of speech, may economy of the recipient's mental energy be assigned as the cause of force; but that in the choice and arrangement of the minor images, out of which some large thought is to be built up, we may trace the same condition to effect. To select from the sentiment, scene, or event described, those typical elements which carry many others along with them; and so, by saying a few things, but suggesting many, to abridge the description, is the secret of producing a vivid impression. An extract from Tennyson's 'Mariana' will well illustrate this:

> 'All day within the dreamy house
> The door upon the hinges creaked,
> The blue-fly sung i' the pane, the mouse
> Behind the mouldering wainscot shrieked,
> Or from the crevice peered about.'

The several circumstances here specified bring with them many appropriate associations. Our attention is rarely drawn by the buzzing of a fly in the window, save when everything is still. While the inmates are moving about the house, mice usually keep silence; and it is only when extreme quietness reigns that they peep from their retreats. Hence, each of the facts mentioned, presuppos-

ing numerous others, calls up these with more or less distinctness, and revives the feeling of dull solitude with which they are connected in our experience. Were all these facts detailed, instead of suggested, the attention would be so frittered away that little impression of dreariness would be produced. Similarly in other cases. Whatever the nature of the thought to be conveyed, this skillful selection of a few particulars which imply the rest is the key to success. In the choice of competent ideas, as in the choice of expressions, the aim must be to convey the greatest quantity of thoughts with the smallest quantity of words."[1]

But Mr. Spencer does not rest content with deducing what may be called the adventitious charms of poetry from this principle; he even thinks that its distinctive characteristic—the restrictions of metre—may be explained by the same law. "The pleasure," he says, "which its measured movement gives us is ascribable to the comparative ease with which words metrically arranged can be recognized."[2] Most people will be startled at the first sight of this bold dictum, but Mr. Spencer is not the man to shrink from the logical consequences of his principles, and they lead to more than this.

Any one who has attentively read the article, or even the brief *résumé* of it just given, will have seen that the theory furnishes a canon for determining, with some degree of certainty, which of two styles is the better. To quote again: "The relative goodness of any two modes of expressing an idea may be determined by observing which requires the shortest process of thought for its comprehension."[3]

Clearly, then, there must, in every case, be some form of expression which is absolutely the best; in other words, there is such a thing as an ideal style. Mr. Spencer accepts the conclusion, but at the same time reminds us that style must vary with its subject-matter.

"The perfect writer will express himself as Junius, when in the Junius frame of mind; when he feels as Lamb felt, will use a like familiar speech; and will fall into the ruggedness of Carlyle when in a Carlylean mood."[4]

The reservation is a proper one, and with it the argument seems unimpeachable. Yet when Mr. Spencer throws the conclusion into the form of an epigram, and tells us that "to have a specific style is to be poor in speech,"[5] he makes the utmost possible demand upon our loyalty to exact reasoning. Like Adeimantus in "The Republic," we are "confounded by this novel kind of draughtsplaying, played with words for counters."

But if the foregoing theory be carefully reviewed, it will be seen that throughout it the treatment is what may be described as objective rather than subjective. Or, to avoid words in which there is a degree of ambiguity, the definite product language is more or less isolated

[1] "Philosophy of Style," p. 34. [2] Ibid., p. 39. [3] Ibid., p. 33.
[4] Ibid., p. 48. [5] Ibid., p. 47.

from the agency using it, and viewed more in relation to the reader's than the writer's mind. But there is another aspect of the relation, which cannot be left out without producing a result which must be one-sided, and may be inaccurate. The following pages will be an attempt to supply this omission by a consideration of the nature of the various devices of language, regarded as the outcome of the mind that employs them.

That "to have a specific style is to be poor in speech" has not been implied in the judgments which the world has from time to time passed upon its greatest writers. Perhaps it would be nearer the truth to say that much in proportion as an author has reached a high eminence in his art, there has been found in his productions a corresponding tendency to an individuality of expression. Is it not a common complaint against inferior artists, whether in prose or verse, in painting or music, that their compositions lack character and originality? Uniformity is the distinguishing feature of mediocrity, while the work of genius is at once recognized and attributed to the origin whose impress it bears. And a little reflection will show that this is exactly what is meant by "style." Various tricks of voice, gesture, and dress, are associated by every one with his friends, glimpses of the hidden self being granted in such half-unnoticed revelations. The chief value, indeed, of such peculiarities rests in the fact that they are commonly unknown to the man himself. For all of us, even the most sincere, are to a certain extent actors in our intercourse with others, and play a part that has been self-assigned, often without due pondering of the player's power. Nature, however, peeps out in countless little traits of character, which find their expression in language, habit, and even in movements. By what subtile union such tricks of manner are linked with what Dr. Johnson has called "the anfractuosities of the human mind," is a curious and intricate question, but no one will doubt the fact of the connection. "That's father!" cries the child as she hears the well-known foot-fall in the hall; "How like the man!" we exclaim, when some characteristic remark is reported to us. Spite of the progress in complexity from a sound to a sentiment, each obeys the same law; and the connection between the foot-fall and the foot, between the speech and the mind that conceived it, is one and the same.

Let us follow out the thought a little further. Not only, to put the fact in its popular aspect, has every one his peculiarities; but there are degrees of peculiarity accompanying degrees of individuality; as a man deviates in *character* from the type ordinarily met with, so are his *habits* singular to himself, till a point is reached where the personality is remarkable, and the behavior eccentric. Where such manners are perfectly unaffected they are a reflection of a self that stands alone among many, so that the common dictum, that genius is eccentric, has a philosophical foundation. There is no need to linger

on the numerous and tolerably obvious reservations which make it impossible to convert the proposition—in other words, to infer unusual power from singularity; the broad fact remains that where there is that marked originality called genius, it is an originality not of thought, emotion, or pursuits, but of the man.

The application of this to literary style is easy, and will be found to lead to some interesting results.

In its powers of direct expression, language is tolerably efficient, and were there nothing but facts, considered objectively, to be conveyed, even a simpler vehicle would suffice. Swift, in one of the most humorous passages of "Gulliver's Travels," describes a set of philosophers, who, disdaining language as the ordinary means of expressing their thoughts, preferred to carry with them a pack of the things most commonly referred to in every-day parlance, by the dexterous manipulation of which they contrived to carry on long conversations. Now this represents, with the necessary freedom of caricature, a real truth with regard to a certain class of discourse. In any written composition, the less the author's personality is involved in the matter treated, the simpler the language which suffices. The extreme form of this truth is found in the case of algebra, where the discourse is, so to speak, perfectly dispassionate, and the symbolism perfectly adequate. Similarly, the language employed in mathematical proof is found adequate in proportion as the statements are purely objective. As we ascend in the scale of literary composition the author's personality creeps in, and brings with it a corresponding complexity of language, not merely the complexity of structure of sentences, but of choice of words, use of figures of speech, and all the refinements of elaborate writing. It is true that much more than this has to be taken into consideration; the subjects themselves are infinitely more complex as the scale is ascended, the distinctions are more delicate, the contrasts present more sides to view, the gradations are subtiler. But is not this a corollary from the main principle? Is it not because we are then dealing either with facts of our own or the general consciousness; with ideas, emotions, desires, and so forth; or at any rate with external facts looked at from the point of view of an interested and questioning observer, that there is this increase in complexity, or, in other words, decrease in adequacy of language?

But this idea admits of yet further development. The facts perfectly expressed in algebraical symbols receive a nearly perfect expression in mathematical language. The terminology of science is found very tolerably sufficient, if strictly adhered to, and mostly where expository and descriptive. In history and biography what we may call the subjective element is strong, and there we find all the refinements of composition. These express, not only facts and aspects of facts, not only are there delicate implications of expression, embodied in all the recognized figures of rhetoric, the trope, the simile, and the

metaphor; but there are the glimpses at the very self of the author which lurks in unconscious tricks of diction and turns of thought, and emerges in epithets, in repetitions, and in phrases. In poetry the author reigns supreme, and there too the imperfection of language is most manifest. In a very fine passage every word is charged with meaning and riveted to its place; in fact, the vehicle is strained to its utmost to bear the load imposed upon it. Hence Coleridge's well-known definition of poetry as "the best words in the best order." Meanwhile the personality of the poet pervades every line of every poem, a hardly recognized but unfailing presence. He colors each picture, and is a spectator at every scene; he is beside Ulysses in the island of Calypso; with him he witnesses the death of Argus and the insolence of the suitors; he shares the recognition of Penelope and the welcome to home; and when dire retribution seizes the usurpers he looks upon their fall.

Not that this personality is directly obtruded upon the hearer's notice; in the instance of Homer, it is markedly withdrawn, the characters speak of themselves, the descriptions are meant to serve no moral end. But what is never brought before us as an avowed element in the composition is everywhere present in the form of the narrative—we never hear the accents of the voice, though we are always listening to its tones. Take as an illustration of this a passage of pure description from the "Odyssey:"

*Ηὗρ μὲν ἐπ' ἐσχαρόφιν μέγα καίετο, τηλόθι δ' ὀδμὴ*
*κέδρου τ' εὐκεάτοιο θύου τ' ἀνὰ νῆσον ὀδώδει*
*δαιομένων· ἡ δ' ἔνδον ἀοιδιάουσ' ὀπὶ καλῇ,*
*ἱστὸν ἐποιχομένη χρυσείῃ κερκίδ' ὑφαινεν.*
*ὕλη δὲ σπέος ἀμφι πεφύκει τηλεθόωσα,*
*κλήθρη τ' αἴγειρός τε καὶ εὐώδης κυπάρισσος.*
*ἔνθα δέ τ' ὄρνιθες τανυσίπτεροι εὐνάζοντο,*
*σκῶπές τ' ἴρηκές τε τανύγλωσσοί τε κορῶναι*
*εἰνάλιαι, τῇσίντε θαλάσσια ἔργα μέμηλεν.*
*ἡ δ' αὐτοῦ τετάνυστο περὶ σπείους γλαφυροῖο*
*ἡμερὶς ἠβώωσα, τεθήλει δὲ σταφυλῇσιν·*
*κρῆναι δ' ἐξείης πίσυρες ῥέον ὕδατι λευκῷ,*
*πλησίαι ἀλλήλων τετραμμέναι ἄλλυδις ἄλλη.*
*ἀμφὶ δὲ λειμῶνες μαλακοὶ ἴον ἠδὲ σελίνον*
*θήλεον· ἔνθα κ' ἔπειτα καὶ ἀθάνατός περ ἐπελθὼν*
*θηήσαιτο ἰδὼν καὶ τερφθείη φρεσὶν ἧσιν.*

*Odyssey*, v., 59–74.

(A large fire was burning on the hearth, and at a distance the smell of well-cleft cedar, and of frankincense, that was burning, shed odor through the island; but she within was singing with a beautiful voice, and going over the web, wove with a golden shuttle. But a flourishing wood sprung up around the grot, alder and poplar, and sweet-smelling cypress. There also birds with spreading wings slept, owls and hawks, and wide-tongued crows of the ocean, to which maritime employments are a care. There a vine in its prime was spread about the hollow

grot, and it flourished with clusters. But four fountains flowed in succession with white water, turned near one another each in different ways; but around there flourished soft meadows of violets and of parsley. There indeed even an Immortal coming would admire it when he beheld, and would be delighted in his mind.—*Buckley's Translation.*)

An analysis of this passage which points out its beauties will be found also to draw attention precisely to those parts where the author's presence is latent. The smell of the cedar, and the voice of the divine songstress accompanying the music of her loom, are, by the epithets "fragrant" and "sweet," made part of the real or imagined experience of the poet; while the word *ἐποιχομένη* suggests, and just suggests, glimpses that he catches of her form as she moves at her work within the cave. Then he describes the wood that shades her abode, implying, by an epithet, how that too appeals to another sense, joining with the incense that burns close by in a mixture of pleasant smells. Another feature is introduced: there are birds harboring in the branches, and the word *εὐνάζοντο* that describes this, by an implied comparison with the sleeping-chambers of man, shows a sort of tender way of looking at Nature. It is more than if it were merely said, "There were birds in the branches." Again, the allusion to the sea in the words *τῇσίντε θαλάσσια ἔργα μέμηλεν* is a direct reflection of the poet's, in no way forming part of a description merely meant to call up an actual scene, instead of a particular way of looking at a scene. The same is true of the words that describe the vine, bending with its burden of ripe clusters, of the labyrinth of streams, and the patches of violet and parsley round them; the accompanying adjectives draw attention to beauties the poet has noticed, and wishes us to notice as well. There is hardly need to point out how the words with which the whole concludes are but an exclamation of wonder and admiration on the part of the poet at the scene he has called up.

But this is not all, for besides the selection of these various elements there is the mode of their combination into a definite picture, the order in which the images follow one another, and the gradation and transition of ideas which are all part of the art, that is, of the mind—of the *self*—of the author. At a distance the senses of sight and smell are first caught by the glimmer of the fire and the fragrance of what is burning in it; as Hermes approaches he hears the sound of the goddess singing at her work; coming still closer, he has leisure to mark the minute details of the scene—the cavern, the grove, and the vine; while the words *ἀθάνατός περ* in the concluding lines leave him in amazement at the beauty of the whole.

Now, this may sound like hypercriticism, and it would be hypercriticism if it were meant that all these points were before the mind of the poet, forming part of an intentional study of effect. On the contrary, the implication is the direct reverse. It is because Homer was such or such a man, because he had been in the habit of regard-

ing what he saw after a certain fashion of his own, that when he set himself to compose poetry he composed it as he did. Hence there is a deep meaning in the saying of Milton, that he who would write good poetry must make his life a poem. It is by virtue of a thousand minute traits of character, the gradual deposit of life's experiences, that any one speaks, writes, even walks and moves, as we see him do. For there must be some reason why, if two men set about describing a scene, or giving even a plain, unvarnished account of some event, the mode of their narration differs—differs, too, in such a way that each can be ascribed to its author, as we say, by internal evidence, that is, by its style. While, then, no better explanation appears, that theory of style may perhaps be provisionally accepted which identifies it with character—with unconscious revelations of the hidden self.

This conclusion needs a little further elaboration before it is compared with that view of what is called the philosophy of style, which resolves all the devices of composition into schemes for economizing the reader's attention. It is necessary to point out, and this may be done briefly, how not only is style generally the impress of the author's self, but that there is a correspondence between the distinctive features of any particular passage and the points at which, in the manner just indicated, the writer's personality glides into the discourse. This is not difficult, if what has been already said be accepted. What, indeed, is meant by saying that an author is best where his writing is most natural?

Is it not implied that the happiest touches are those which are original—that those phrases and expressions are most welcome to the reader which set the matter they convey in a new light—and that the light in which the writer himself sees it? If the foregoing passage from the "Odyssey" be reviewed, it will be found that its beauties are coincident with the parts where the presence of the poet seems to be hinted, and this is equally true, though not equally discernible, in all writing that is at all elaborate.

Now, how does all this square with the dictum that "to have a specific style is to be poor in speech?" It will not at first sight appear so very incompatible. In a certain sense, style at all owes its existence to the imperfection of the vehicle of thought. Were language a perfectly adequate means of embodying ideas, what is now to be looked for in the *mode* of statement would be found directly declared in the statement itself. For the countless devices of language, the gestures and tones of discourse, the thousand rhetorical figures of written composition, are really one and all simple propositions not capable of exact expression in the body of the narrative. They are the lights and shades of the picture, or perhaps rather the finer touches, which are to tickle the imagination of the reader with suggested beauties. And it is exactly in these refinements of expression that the deepest meaning of any author, in other words, his *self*,

resides. There is something pathetic in the reflection that we walk this world half hidden from one another, a constant struggle going on to make known the thoughts, beliefs, and aspirations of the real but partly-imprisoned being, which never can be known exactly as they are to any but the mind that conceives them. Like savages, we speak mostly by signs, which serve us well enough, but leave much uncommunicated. It is well, however, that this imperfection is an imperfection that produces beauty; that the grating of the machine is not harsh, but musical. Mr. Herbert Spencer is successful in showing that the various devices of language do serve to the economy of the reader's attention, and that beauties of style are beauties partly because they effect this end. But he has not raised a question which seems closely akin to the subject. Why is it needful to have recourse to these expedients at all, and why is there an infinite variety in every man's use of them? The answer to these questions seems to give an insight into a higher law, to which Mr. Spencer's principle stands rather as an empirical generalization. It is this: that each man's inmost nature is a secret to all but himself—and that a secret which in no two cases is the same. Every attempt to communicate it partly fails, and so language is full of compromises and expedients; each nature to be revealed is different, and so there is a countless variety of styles. This, then, is not due to poverty of speech; rather it is due to multiplicity of individualities, each speaking its own language and telling its own tale.

The ideal style, then, is for an ideal being, but for an ideal being who is to be without personality. The perfect writer may write, now like Junius, now like Lamb, now like Carlyle, but like himself he can never write. He cannot, as we say, *express himself*. A significant phrase, for after all it is when a man, as far as he can, expresses *himself*, that his communication is most worth having. It is the one thing of which he certainly knows something, where he can indeed speak with authority. It is not so much what a man knows as how he knows it, not so much the extent as the quality of his information, that gains him a right to be heard. Originality is far oftener originality of expression than idea, a fresh aspect of something old, not a discovery of something new. And so there starts up here an answer to the difficulties encountered at the outset, "Why men are influenced by language at least as much as by ideas;" and "Why power of expression is intimately associated with mental grasp generally." Partly, no doubt, because in language resides the personality of the speaker or writer, and men are influenced by personality—but far more for another reason. The highest form of ability is something which pervades the whole being; it is not restricted to an intellect preternaturally acute, to vividness of imagination, or fineness of feeling; but it is the manifestation of a nature—of a *self*, which is really great. And it has been seen that it is in expression, or style, that the self of

the author is to be sought. That, then, is a true instinct which so intimately associates power of expression with power of character generally. Of this power, too, the distinguishing feature is its individuality. Just as in animal life the ascent of the scale of creation is a process of differentiation of functions; just as a higher form of life is marked off from a lower form by greater specialty of shape, by powers more accurately defined, by habits more peculiarly its own: so in the comparison of man with man, something similar to this law is traceable, pointing out that the superiority of genius in degree is mainly a consequence of its difference in kind.

Thus Nature seems to speak in a continued protest against uniformity, by a thousand analogies insisting upon the supreme importance of the individual. And the critical verdict which pronounces that writing best which is the most natural can be affiliated to as wide a law as this. Whether or not it be thought that each man is put into the world the possessor of some particular truth, which his acts or words can set before his fellow-creatures, it is at any rate clear that the inevitable specialty of each man's experiences must present things to him in an aspect which can be exactly the same for no other. There are no real *doubles* in the world, no such thing as identity in constitution and circumstances. While, then, this is so, there is a significance in style, a value in the unconscious self-revelations of traits of personality. However a man may fail of the object he sets before him in what he does or says, yet if there has been in him that conscientious fidelity to his purpose, which is but an attempt to express *himself*, his work will not have been wasted, though its direct worth be unimportant.—*Macmillan's Magazine.*

## OUR SIX-FOOTED RIVALS.

II.

EVEN more wonderful than the mere intelligence of the ant is its power of organization—the point, probably, in which it approaches most closely to man. Suppose that ants, instead of forming nations, lived like most creatures, merely in pairs, each endeavoring to rear a young brood, who, when mature, would enter upon a similarly isolated career. Let them be as brave, as intelligent, and as strong, as they now are, still how humble and insecure would be their position! Against the attacks of the giant spiders, centipedes, hornets, and wasps of warm climates, they could make no effectual resistance. Prey, which in their present condition they easily secure, would escape them, or would scarcely even notice their puny efforts. In short, there is every reason to believe that many of their species would become extinct, and that the remainder would live, so to

speak, mainly on sufferance, playing no appreciable part in the economy of the globe. Turning from this hypothetical survey of the ant as an individual, unorganized being to its actual condition, we see the most striking contrast. Mr. Belt gives the following graphic account of the excitement caused by a marching column of *Ecitons* in the primeval forests of Nicaragua: "My attention was generally first called to them by the twittering of some small birds belonging to different species. On approaching, a dense body of the ants, three or four yards wide, and so numerous as to blacken the ground, would be seen moving rapidly in one direction, examining every cranny and underneath every fallen leaf. On the flanks, and in advance of the main body, smaller columns would be pushed out. These smaller columns would generally first flush the cockroaches, grasshoppers, and spiders. The pursued insects would rapidly make off, but many, in their confusion and terror, would bound right into the midst of the main body of ants. At first, the grasshopper, when it found itself in the midst of its enemies, would give vigorous leaps, with perhaps two or three of the ants clinging to its legs. Then it would stop a moment to rest, and that moment would be fatal, for the tiny foes would swarm over the prey, and, after a few more ineffectual struggles, it would succumb to its fate, and soon be bitten to pieces and carried off to the rear. The greatest catch of the ants was, however, when they got among some fallen brushwood. The cockroaches, spiders, and other insects, instead of running right away, would ascend the fallen branches and remain there, while the host of ants were occupying all the ground beneath. By-and-by, up would come some of the ants, following every branch, and driving before them their prey to the ends of the small twigs, where nothing remained for them but to leap, and they would alight in the very throng of their foes, with the result of being certainly caught and pulled to pieces.

"The moving columns of *Ecitons* are composed almost entirely of workers of different sizes, but, at intervals of two or three yards, there are larger and lighter-colored individuals that often stop and sometimes run a little backward, stopping and touching some of the ants with their antennæ. They look like officers giving orders and directing the march of the column.

"The ants send off exploring-parties up the trees, which hunt for nests of wasps, bees, and probably birds. If they find any, they soon communicate the intelligence to the army below, and a column is sent up immediately to take possession of the prize. I have seen them pulling out the larvæ and pupæ from the cells of a large wasps' nest, while the wasps hovered about, powerless, before the multitude of the invaders, to render any protection to their young."

Still more formidable are the "driver-ants" of tropical Africa, so called because, on their approach, even the lion, the elephant, and the huge python, at once betake themselves to flight.

Nor are the purely vegetarian ants of less importance in the economy of the countries they inhabit. They decide, in a manner, what trees shall grow and what shall be exterminated, and it is only such as are comparatively distasteful to them that escape. In Nicaragua, they render the acclimatization of any foreign tree or vegetable a task of great difficulty. Mr. Belt was often told, on asking the reason why no fruit-trees were grown at certain places: "It is of no use planting them; the ants eat them up." These ants climb up the trees, when "each one, stationing itself on the edge of a leaf, commences to make a circular cut from the edge with its scissor-like jaws, its hinder feet being the centre on which it turns. When the piece is nearly cut off, it is still stationed upon it, and it looks as though it would fall to the ground with it; but, on being finally detached, the ant is generally found to have hold of the leaf with one foot, and, soon righting itself and arranging its burden to its satisfaction, it sets off at once on its return."

An observer, standing near the ant-hills, "sees from every point of the compass ant-paths leading to them, all thronged with the busy workers carrying their leafy burdens. As far as the eye can distinguish their tiny forms, troops upon troops of leaves are moving up toward the central point and disappearing down the numerous tunneled passages. The ceaseless toiling hosts impress one with their power, and one asks, 'What forests can stand before such invaders?'" Concerning the use to which the ant-leaves are put, some difference of opinion prevails; that they do not directly serve as food is admitted. Mr. Bates, from observations made in Brazil, concludes that "the leaves are used to thatch the domes which cover the entrances to their subterranean dwellings, thereby protecting from the deluging rains the young brood in the nests beneath." Mr. Belt, who has carefully examined the habits of an allied species in Nicaragua, believes that the real use they make of them is as a manure, on which grows a minute species of fungus on which they feed—that they are, in reality, mushroom growers and eaters. The reasons for this view are given in detail in Mr. Belt's work, and appear very satisfactory. But Mr. Bates's view may be correct also. In short, save man alone, there is no creature which can effect such wide-spread and profound alterations in the condition of a country as the tiny ant. It has been indeed mentioned in the *Quarterly Journal of Science* that the pig, the goat, and the rabbit, have succeeded in extirpating the natural flora, and consequently, to a great extent, the fauna, of certain islands, such as St. Helena. Yet this takes place only in countries where there are no carnivorous beasts, birds, and reptiles, to keep them in check. But in every warm and fruitful climate the ant is king. This power, we perceive, is not due to mere numbers; it is, in great part, the result of organization. Other species of insects are perhaps even more numerous, and, individually considered, as capable of destructive action;

but locusts, potato-beetles, mosquitoes, noisome as they may be considered, are, in comparison with ants, what a promiscuous mob is in comparison with a well-trained and organized army. Each ant, like an experienced soldier, knows—whether rationally or instinctively it matters not—that it will be systematically supported by its comrades. What would be the prospects of agriculture in Western Asia, in Northern Africa, or in the Western States of the American Union, if the locusts, when engaged in desolating a field, were to attack, *en masse*, any man or bird who should interfere with them? But, on the contrary, they allow themselves to be slaughtered in detail, each indifferent to the fate of his neighbor.

Ants evince that close mutual sympathy which, to an equal extent, can be traced probably in man alone, and which has, in both these cases, proved one of the primary factors in the development of civilization. Had man been devoid of this impulse, he would have remained a mere wandering savage—perhaps a mere anthropoid, occurring as a rare species in equatorial districts. Without a similar impulse, the *Ecitons* would have ranked among the many solitary species of *Hymenoptera*. Of the mutual helpfulness of these same *Ecitons*, Mr. Belt gives us some most interesting cases which came under his own observation: "One day, when watching a small column of these ants (*Eciton hamata*), I placed a little stone on one of them to secure it. The next that approached, as soon as it discovered its situation, ran backward in an agitated manner, and soon communicated the intelligence to the others. They rushed to the rescue: some bit at the stone and tried to move it; others seized the prisoner by the legs, and tugged with such force that I thought the legs would be pulled off; but they persevered until they got the captive free. I next covered one up with a piece of clay, leaving only the ends of the antennæ projecting. It was soon discovered by its fellows, who set to work immediately, and, by biting off pieces of the clay, soon liberated it. Another time I found a very few of them passing along at intervals. I confined one of these under a little piece of clay, with his head projecting. Several ants passed it, but at last one discovered it and tried to pull it up, but it could not. It immediately set off at a great rate, and I thought it had deserted its comrade; but it had only gone for assistance, for in a short time about a dozen ants came hurrying up, evidently fully informed of the circumstances of the case, for they made directly for their imprisoned comrade, and soon set him free. The excitement and ardor with which they carried on their exertions for the rescue could not have been greater if they had been human beings."

Such cases as these are of the greater moment because many other social and semi-social animals treat an unfortunate companion in a very different manner. It is on record that a rook, which had got entangled among the twigs of a tree, was pecked and buffeted to death by its neighbors, despite the efforts of its mate for its protection.

Facts are not wanting which show that the social organization of ants takes cognizance of sanitary matters. In Australia they have been known to bury their dead, not without some degree of formality[1] according to their caste. In experimental formicaries in this country, ants have been observed to throw the bodies of their dead companions into the water surrounding their dwellings. In the nests of almost all species great care is taken to preserve cleanliness. The agricultural ant of Texas removes any offensive matter placed near its city, and will even take the trouble to carry away the droppings of cattle that have fallen on its cleared ground. Any dung-rolling beetle which brings its ball of ordure within these sacred precincts is at once attacked and put to death, and the nuisance is quickly cut to pieces and carried to a distance.

Nor are laws on other matters wanting. Ants who have, from some unknown cause, refused to work have been observed to be put to death. Among the agricultural ants, prisoners have been known to be brought in by a fellow-citizen and handed over in a very rough manner to the guards, who are always on duty on the level ground before the city, and who carry off the offender into the underground passages. What is his after-fate is not known. It is almost needless to point out that even the faintest rudiment of law proves the existence of some notions of right and wrong, as well as of a power of communication which must go into minute details.

We have now to deal with the great question whether the civilization of ants, like that of man, has been gradually and slowly developed by the accumulation of experience, or whether—as the believers in the fixity of habits and instincts still contend—it is primordial, coexistent with the species in all the details which we now observe. Direct historical evidence is here yet more difficult to obtain than as concerns animal structure. We smile, with just reason, at the French *savants* of the Egyptian Expedition, who imagined that, by the study of the animal-mummies there preserved, they might gain some light on, or rather find some argument *against*, the mutation of species. At the same time, we readily admit that, could we find a complete series of skeletons, anatomical preparations, or even photographs of the best-known animals, made at intervals of a century, and extending backward for say a hundred thousand years, the doctrine of evolution would be brought to a crucial test. But, concerning the former habits and instincts of animals, correct information is far more difficult to obtain. The "stone-book" is silent or oracularly vague. Even if we had written documents left us by some naturalist of the Miocene ages—if we can suppose such a being to have existed—what security should we have for the accuracy and the completeness of his researches?

To meet this difficulty an attempt, remarkable for its subtile in-

[1] *Journal of Linnæan Society*, vol. v., p. 217.

genuity, has been made by Prof. Heer. He points out that, according to the reckoning of the most discreet geologists, at least a thousand centuries must have elapsed since Britain was severed from the Continent of Europe. For this long stretch of time, therefore, British animals must have been cut off from their representatives in France, Belgium, and Switzerland. If, then, the habits of a certain slave-holding ant (*Formica sanguinea*) in England are found identical, as he maintains, with the habits of the same species in Switzerland, there is a strong presumption that its economy has undergone no change for the last hundred thousand years. To this argument, we must reply that the isolation between British and Continental species of insects is by no means so complete as is here assumed. Winged ants travel very considerable distances, and, if our memory does not deceive us, have been met with out at sea. That a part of a swarm should be blown over from the French coast to England, or *vice versa*, is by no means improbable. And it is well known that if a party of working-ants fall in with an impregnated female of their own species, they immediately lead her to their nest and install her in a royal apartment. That there may have been within the last ten thousand—or even one thousand—years direct intercommunication of this kind between the slave-making ants of England and those of Switzerland, seems to us fully more probable than the contrary supposition.

Again, we may ask whether the conditions under which ants would be respectively placed in Switzerland and in England are not so closely analogous that their social development must proceed on parallel lines? In both they would encounter nearly the same climate, the same food, and the same enemies. Surely, therefore, a close correspondence in habits is no decisive proof of their immobility. But, after all, is there such an absolute accord between the habits of the Swiss and of the British ants as the validity of Prof. Heer's argument would require? Mr. Darwin thinks that in the nests of the British *Formica sanguinea* there is a relatively smaller proportion of slaves, which therefore play a less important part in the economy of the ant-hill. Messrs. Kirby and Spence record a fact which, isolated as it is, seems to us to overthrow altogether the hypothesis of absolute stationariness. Ants have been found, namely, to establish their nest in the interval between the double casing of a glass beehive. Now, as such beehives are artificial objects, and of very recent origin, they cannot have come in the way of the ants for any great length of time. They offered, however, a certain advantage in the uniform temperature and the shelter which they supplied. This fact must have been recognized by some prying ant, and the discovery, being communicated to its comrades, was turned to practical account. Is not this case the exact parallel of a step in the development of human civilization? And if, as we see, ants can in one case observe a phenomenon, reason on such observation, and work out their conclusions

in their daily life, we can certainly see no grounds for supposing that such processes may not have occurred often. In the case of larger animals, where observation is easier, changes of habits, in accordance with new facilities or new dangers, have been distinctly recognized. There can be no necessity for us to quote the cases of alterations in the nidification of birds given by Mr. Wallace.[1] Recent American observations show that the habits of many birds, mammalia, and even fishes, have undergone a very decided alteration in settled districts as compared with less frequented regions. All species have become more wary and circumspect in their movements, and are decidedly more nocturnal. The birds build their nests on higher trees, or in the densest thickets. Any unusual object placed in a river alarms the fishes more than a similar object would have done some years ago, and more than it does now in solitary parts of the country. A new danger is recognized, and precautions are taken accordingly.

On carefully examining the habits of ants, we find that there exist among closely-allied species, and even in different colonies of one and the same species, gradations which, to our mind, supply powerful evidence that such habits cannot have been primordial. The slave-making propensity, and the reliance placed upon slaves, occur in several species, but not to the same degree. *Polyergus rufescens*, for instance, is absolutely dependent upon its slaves, and would, without them, perish from sheer incompetence to manage its own affairs further than by conducting slave-hunts. It is a military aristocracy, which can fight, but will rather die than work. *Formica sanguinea*, on the other hand, has much fewer slaves, and restricts them to a much narrower sphere of duties, being itself capable of working as well as of fighting. It is curious that the raids of slave-holding ants are confined to worker-pupæ of the species which they subjugate. No instance has reached us of ants carrying off male and female pupæ with a view to raising a stock of slaves in their own city, without the necessity of obtaining them by war. Surely, the most rational way of accounting for this slave-making propensity is to suppose that, as in the human race, it is a gradual outcome of war. Ants, in the wars which they are known to wage against different species, as well as against their own, would take prisoners—an undeniable fact—with the original intention of killing and devouring them. Some few of these victims, escaping immediate slaughter, might, if of a docile and submissive disposition, be found useful, and might hence be allowed to live in servitude. Prisoners of fiercer and more indomitable species, if taken at all, are no doubt killed. The query here naturally arises: "What happens in the not infrequent wars between two cities of the same species? Are the prisoners slaughtered, or are they incorporated with the victorious nation?"

No less variation may be traced in the habits of the cattle-keeping

[1] "Contributions to the Theory of Natural Selection," p. 227.

ants. Of the honey-secreting Aphides, and *Cocci* that serve them as milch-kine, some have large herds, some small ones, while others have none at all, and if they encounter an *Aphis* straightway kill and eat it. Is it not more probable that the ants first sought Aphides, like other insects, for this very purpose, but gradually discovered a way to turn them to better account, than that a flock of Aphides was, by some wonderful coincidence or interposition, placed within the reach of the first ant-hill?

It would, therefore, in our opinion, be exceedingly imprudent to declare that ant-civilization has not advanced, may not now be advancing, and may be destined to take yet further steps in the future, especially if large and fruitful portions of the globe are long allowed to remain in an uncultivated or semi-cultivated state. But such advances must necessarily be slow, as in all cases where there are no means of recording the experience of one generation for the benefit of the succeeding, and where what among mankind would be known as oral intercourse is limited by shortness of life. What direction these future advances may take, it is as difficult to indicate as to foretell the discoveries and inventions to be made by man during the next century. But we may safely say that they will not consist in the introduction of tools or weapons or machinery. Were man, in proportion to his size, about twenty times as strong as he is at present—were he provided by Nature with a pair of forceps, playing laterally, and capable of being used for felling trees, for excavating the ground, or for cutting off the heads of his enemies—he would scarcely have been a tool-inventing and tool-using animal. A being which, like the Sauba ants of Brazil, can construct a tunnel underneath the bed of a river as wide as the Thames at London Bridge, is in no need of shovels, pickaxes, or barrows.

That ants, in tropical climates, occasion much loss and annoyance to man is indisputable; yet the annihilation of all kinds of ants, were such a measure practicable, would scarcely be prudent. Here, as elsewhere, the rule holds good that small carnivora are to be cherished, and small herbivora and omnivora destroyed. The carnivorous ants, such as the *Ecitons*, are invaluable, from the myriads of cockroaches, scorpions, centipedes, venomous spiders, grasshoppers, and even rats and mice, that they destroy. They keep down serpents, also, by devouring their eggs. The plant-eaters, on the contrary, and especially the leaf-cutters, are an unalloyed evil, and their destruction ought to be attempted in a much more systematic way than what takes place at present. Nor can the "cattle-keeping" ants be tolerated. Even though they may not, in their own persons, attack the fruits and the leaves of useful trees, they compass injury to the latter by cherishing and defending swarms of such pernicious vermin as the Aphides of temperate regions and the scale-insects and tree-hoppers of warmer climates. All these live by sucking the juices of plants,

and over them the ants watch with a wonderful care, defending them from the attacks of birds, wasps, ichneumons, and other creatures, who would rid the poor plant of its parasites. They have even been known to build galleries of clay over the surface of a pine-apple, in order to shelter the *Cocci* who were destroying the fruit.

Mr. Belt found that a red passion-flower, which secretes honey from glands on its young leaves and on the sepals of its flower-buds, was carefully guarded by a certain species of ant (*Pheidole*), who consumed the honey, and who furiously drove off all leaf-cutters and other intruders. But, after a couple of seasons, a colony of parasitical scale-insects, which secrete honey, established themselves upon the passion-flower, to its great injury. The ants transferred their care and attention to these, and, from the guardians of the plant, became indirectly, but not the less substantially, its enemies. This is a striking proof of the untrustworthy character of our insect—or, more generally speaking, of our animal—allies. At one moment they may be defending our property from depredation, but on a slight change of circumstances their interests may cease to coincide with our own, and they may go over to our enemies. The question what animal species we ought to protect and which to destroy, and how far we ought to go in each case, becomes, on closer inspection, exceedingly complicated.

As an example of an omnivorous ant, we may take the "fire-ant" of the Amazon, of which Mr. Bates gives us a striking account:[1] "Aveyros may be called the headquarters of the fire-ant, which might be fittingly termed the scourge of this fine river. It is found only on sandy soils, in open places, and seems to thrive more in the neighborhood of houses and weedy villages, such as Aveyros; it does not occur at all in the shades of the forest. Aveyros was deserted a few years before my visit on account of this little tormentor, and the inhabitants had only recently returned to their houses, thinking its numbers had decreased. It is a small species, of a shining reddish color, not greatly differing from the common stinging ant of our own country (*Myrmica rubra*), except that the pain and irritation caused by its sting are much greater. The soil of the whole village is undermined by it; the ground is perforated with the entrances to their subterranean galleries, and a little sandy dome occurs here and there, where the insects bring their young to receive warmth near the surface. The houses are overrun with them; they dispute every fragment of food with the inhabitants, and destroy clothing for the sake of the starch. All eatables are obliged to be suspended in baskets from the rafters, and the cords well soaked with copaiba-balsam, which is the only means known of preventing them from climbing. They seem to attack persons out of sheer malice. If we stood for a few moments in the street, even at a distance from their nests, we

[1] "Naturalist on the River Amazon."

were sure to be overrun with them and severely punished, for the moment an ant touched the flesh he secured himself with his jaws, doubled in his tail, and stung with all his might. When we were seated on chairs in the evenings, in front of the house, to enjoy a chat with our neighbors, we had stools to support our feet, the legs of which, as well as those of the chairs, were well anointed with the balsam. The cords of hammocks were obliged to be smeared in the same way to prevent the ants from paying sleepers a visit." The ravages of the leaf-cutting ant (*Oicodona*), or Saubas of the Brazilians, have been already mentioned; but it also invades houses and carries off articles of food on a far wider scale than is ever done by rats or mice. It is capable of carrying off such a quantity as two bushels of mandioca-meal in the course of a single night! Unfortunately, the Sauba has few enemies. The number of these depredators who fall a prey to birds, spiders, wasps, tiger-beetles, etc., is too small to be of any importance. The *Pseudomyrma bicolor* easily repels them if they come to clip the leaves of the bull's-horn acacia on which it resides, but it is not sufficiently numerous to pursue and destroy them. The *Ecitons* have never been known to storm the nests of the Sauba. Thus, as we often find, for the greatest mischiefs Nature provides no remedy, and man must step into the breach, armed with carbolic acid and corrosive sublimate.—*Quarterly Journal of Science.*

## SKETCH OF PROFESSOR JOSEPH LE CONTE.

THE subject of the present notice, now Professor of Geology and Natural History in the University of California, bears a family name that has long been distinguished in American science. He was descended from William Le Conte, a Huguenot, who left his native city, Rouen, on account of the political and religious troubles consequent upon the revocation of the Edict of Nantes, in 1685, and settled in the vicinity of New York. Here his ancestors continued to live until about 1810, when his father, Louis Le Conte, removed to Liberty County, Georgia, to take personal charge of a large inherited estate. There Joseph Le Conte was born, February 26, 1823.

His primary education was received in a neighborhood school of his native county; and, among the ten or twelve different teachers who successively directed his education with varying success, the only one whom he recognizes as having left any decided impression upon his mind was Alexander H. Stephens, afterward the distinguished politician.

The germs of much of his future character and career may be traced to these early boyhood days. His father was an ardent devotee

of science in all its departments, but especially of natural history. The example of his father, and the splendid botanical garden in the midst of which he lived from infancy, early imbued him with an intense love of Nature, and cultivated in him the habit of scientific observation. The unrestrained freedom of his boyhood life, in a country where game of all kinds abounded, engendered a passionate fondness for field-sports; and this again increased both his love of Nature and the opportunities of observation. In later life this love of field and forest took the more rational form of extensive ramblings for scientific purposes.

After graduating A. B. in the University of Georgia, in 1841, he commenced the study of medicine, and graduated M. D. in the College of Physicians and Surgeons of New York, in 1845. A few years of active practice of his profession in Macon, Georgia (during which, however, he was more interested in the *science of medicine* than in the *art of healing*), served to convince him that he had not yet found his appropriate field of activity. He therefore, in 1850, went to Cambridge, Massachusetts, to pursue a course of practical science in the laboratory of Prof. Agassiz.

His life in Cambridge, and especially his intimate association with the great teacher, powerfully stimulated his enthusiasm for science, and permanently determined its direction. During the winter of 1851, in company with Prof. Agassiz, he spent the months of January and February on the keys and reefs of Florida, engaged in studying their mode of formation. These studies afterward gave origin to a paper "On the Agency of the Gulf Stream in the Formation of the Peninsula and Keys of Florida."

In 1851, after taking the degree of B. S. in the Lawrence Scientific School, he returned to Georgia, and was immediately elected to the chair of Natural Science in Oglethorpe University. As this chair included physics, chemistry, geology, and natural history, he was not unwilling to exchange it for that of geology and natural history in the University of Georgia, which was tendered him in 1852. Four years of laborious class-room work here laid the foundation of his success as a teacher and lecturer, but left little time for research. In 1856 he removed to Columbia, South Carolina, to take charge of the chair of Chemistry and Geology in the South Carolina College.

The years spent in connection with this institution were among the pleasantest and most active of his life. The highly-intellectual and refined society gathered in Columbia was, however, more literary and philosophical than scientific. His activity, therefore, took in some degree this direction, and most of his articles which are not strictly scientific were written at this time.

In 1862 the call of the Confederate Government for all able-bodied males over eighteen years of age entirely broke up the college for want of students. During the war he was engaged first as Chemist

of the Government Laboratory for the Manufacture of Medicines, and afterward as Chemist of the Nitre and Mining Bureau.

After enduring the privations and hardships (including the total loss of property) consequent upon the breaking up of the Confederacy, on the reorganization of the college as the University of South Carolina, he was again appointed to the chair of Chemistry and Geology, in the undergraduate department, and of Chemistry and Pharmacy in the medical department. But the utter prostration of the material resources of the State, falling first and most heavily on institutions of higher education, compelled him to seek employment in a more prosperous region. He therefore, in 1868, accepted a call to the chair of Geology and Natural History in the University of California then about to be organized, and removed to that State to assist in the opening of the first session of the new institution, in September, 1869. He has continued to occupy this chair up to the present time.

From this time commenced the most active period of Prof. Le Conte's strictly scientific life. The boundless field for geological studies presented on the Pacific coast incited him to pursue his favorite department with renewed ardor. Every summer vacation was spent in a geological ramble with a party of students and graduates in the high Sierras, or in a geological tour through Oregon, Washington Territory, and British Columbia. As much of the region of the high Sierras is wholly uninhabited, camping-parties were organized; and thus studies of Nature were combined with a life of adventure full of delight, amid the finest scenery in the world. Many scientific papers on the origin and structure of mountain-chains, and on the ancient glaciers of the Sierras, were the result of these studies. Meanwhile other and more abstract subjects were not neglected; for he contributed during this time also many papers on the theory and phenomena of binocular vision.

Prof. Le Conte can hardly be called a specialist in any department, in the narrow sense of that term; for, although his chief activity has been in the field of science, yet his interest in literature, art, and philosophy, is almost equally great. Association alone seems to have determined his life-work in the direction of science. Until thirty years of age his intellectual culture was almost perfectly general. Only after that did it commence to concentrate first on science, and still later on special departments of science. While this may have been a disadvantage in the pursuit of special narrow lines of investigation, it had also its advantage in giving that comprehensiveness so necessary in the more complex departments of science which he had chosen.

In his theory of education, therefore, Prof. Le Conte was always an earnest advocate of the general or liberal education of the cultured man, rather than the special education of the mere expert. His ideal of education was a general culture first, and as high as circumstances

will allow, and then a concentration on special cultures suitable to the intellectual plane to which the pupil has been previously raised by the general cultivation.

Deeply religious in his innermost nature, he nevertheless fearlessly pushed scientific ideas to their legitimate conclusions. He believed that truth cannot conflict with itself; that true science is not antagonistic to a true religion, or *vice versa;* that pride and dogmatism on both sides are the only bar to cordial relations.

The following are some of Prof. Le Conte's principal contributions to literature and science:

1. The Science of Medicine, and the Causes which have retarded its Progress, 1849.
2. Agency of the Gulf Stream in the Formation of the Peninsula and Keys of Florida, 1856.
3. Lectures on Coal, and on Coral Reefs. Smithsonian Institution, 1857.
4. Place of Organic Science and Geology in a Scheme of Education, 1857.
5. Morphology, and its Relation to Fine Art, 1858.
6. Principles of a Liberal Education, 1859.
7. Female Education, 1859.
8. Correlation of Physical, Chemical, and Vital Forces, 1859.
9. Relation of Organic Science to Social Science, 1860.
10. Importance of Natural History in the Schools, and the General Relation of the School, the College, and the University, to each other and to Active Life, 1861.
11. The Nature and Uses of Fine Art, 1863.

*Phenomena and Theory of Binocular Vision—a series of papers, viz.:*

12. I. Adjustments of the Eye, 1868.
13. II. Relation of the Eyes on the Optic Axis in Convergence, 1869.
14. III. The Horoptic, 1869.
15. IV. A New Mode of representing Binocular Phenomena, 1870.
16. V. Theory of Steroscopy, 1871.
17. VI. So-called Images of Illusion, 1872.
18. VII. Position of the Eyes in Sleep, 1875.
19. VIII. Law of Corresponding Points in Relation to the Law of Direction, 1875.
20. IX. Comparative Physiology of Binocular Vision, 1875.
21. X. Structure of the Crystalline Lens, and its Relation to Periscopism, 1877.
22. General Law of Circulation in Nature, 1870.
23. Theory of Formation of the Greater Features of the Earth's Surface, 1872.
24. Ancient Glaciers of the Sierra, 1873.
25. Some Tributaries of Lake Valley Glaciers, 1875.
26. The Great Lava-Flood of the Northwest, and the Structure and Age of the Cascade Mountains, 1874.
27. Structure and Mode of Formation of the Coast Ranges of California, 1876.
28. Instinct and Intelligence, or the Genesis of Instinct, 1875.
29. The True Idea of a University, 1876.
30. Critical Periods in the History of the Earth, and their Relation to Evolution, 1877.

Although his life has been given to the development of original thought in various departments, yet Prof. Le Conte has not had the ambition to be a great book-maker. He, however, published a volume in 1873 on "Religion and Science," and has just issued a comprehensive college text-book of geology, the result of his twenty-five years' experience in teaching that subject.

# CORRESPONDENCE.

## HOW TO PRACTISE MIND-READING.

*To the Editor of the Popular Science Monthly.*

IT is interesting to contemplate that curious phase of credulity, closely allied to superstition, which seems to be innate in the human mind, predisposing many intelligent people to attribute to supernatural agencies certain phenomena which are purely subjective. This quality has, doubtless, contributed to the growth of faith in spiritualism, odylism, auras, psychic force, and what not.

One would suppose that the recent exposure in the law-courts of the juggleries of some of the more notorious mediums would have served to convince the most ardent believers that the so-called spirit-manifestations are wholly mundane. This good result, however, does not appear to have been accomplished as yet.

When "Professor" Brown, the *mind-reader*, performed his clever experiments a few years since, many well-educated people maintained that his discoveries could not be explained by any of the known laws of Nature; he was indorsed by several distinguished scientists, at least one of whom stated that he was a firm believer in Brown, and that he regarded "the theory of unconscious muscular action as entirely opposed to the facts observed."

Since that time quite a number of articles have appeared in this and other scientific journals upon the subject; they have all been devoted to elaborating theories, and I propose, therefore, to confine myself to a few practical hints as to the precise methods of observation, hoping thereby to enable persons interested to perform all of Mr. Brown's experiments successfully, as well as others of a more complex and astonishing character, and, at the same time, to answer numerous queries that I have from time to time received.

The main difficulty that the novice in the art of interpreting "ideo-motor movements" encounters is, that he does not know exactly what indications to look for, and often mistakes an accidental or intentional movement of the "subject" for an involuntary one. He also imagines that the indications are confined to muscular contractions in the arm or hand of the subject. This is a fatal mistake, as I have already shown in a letter to Dr. Beard, which he communicated to your journal in the July number, 1877. In that letter I stated that it is quite possible for the mind-reader to select objects hidden or thought of, walk over any route desired, or to perform any similar experiment, without any connection between his subject and himself, even while he is blindfolded. I also referred to several other novelties, and shall now content myself with a simple explanation of the *modus operandi* upon which the whole principle depends; leaving it to the ingenuity of experimenters to complicate the tests according to their ability.

Let us suppose that the mind-reader has been escorted out of the parlor by a committee appointed by the guests to see that all is fair. A "subject" is then selected who will hide a small article, perhaps a pin, under the carpet in the corner of the room. The mind-reader is led in blindfolded, he takes the left hand of the subject in his left (*à la* Brown), grasping the subject's elbow with his right; he tells the subject to fix his mind intently upon the object hidden and the locality; he then makes *a feint* to move away, watching closely to see whether the subject shows any reluctance to follow him; if so, he tries another direction; presently he will find one point toward which the subject will show a disposition to accompany him very readily. This, then, is the first clew; he follows it up, occasionaliy feigning to diverge, in order to satisfy himself that he is on the right track. In this way he will be guided (not led) past all obstructions to the locality; then he will notice that the subject shows no partiality toward any particular direction. The mind-reader thus infers that he is, in juvenile parlance, *very hot*, and he now, for the first time, directs his attention exclusively to the involuntary movements in the arm of the subject, in order to obtain the indication as to the exact locality of the object hidden. This he accomplishes by moving the subject's arm about until he discovers the direction in which the arm unconsciously *prefers to go*. Should the subject suspect that he may be involuntarily giving the indications, it is a capital *ruse* for the performer, first, to satisfy himself of the position of the object, and, before producing it, to move away from the spot, then suddenly pounce upon it with great show of certainty. The "bull-dozed" subject will at once become the strongest opponent of the involuntary muscular-movement theory!

Apart from the amusement which these performances invariably afford at a social gathering, the subject of the "ideo-motor movements" is one of the highest physio-

logical interest, and very surprising results may be obtained by a careful study of all the conditions, and an ingenious complication of the experiments.

Thus it is quite easy to have half a dozen or more persons engaged in performing parts of an experiment, each one being ignorant of what the other has done. The mind-reader then ravels out the thread by beginning at the end and working backward, or *vice versa*. The rapidity with which the experiments may be performed is remarkable, sometimes occupying less time than is required to arrange them.

The chief points, then, for the beginner to observe are:

1. Impress upon your "subject" the necessity of fixing his mind on the object and its locality.

2. Concentrate your attention on every movement of the subject.

3. Never hazard a guess.

Hoping that these few directions will enable others interested in this entertaining and scientific trick to repeat the experiments successfully, and referring the reader to my previous letter for an explanation of the performances without physical contact, I am, yours, very truly,

ALEXANDER E. OUTERBRIDGE, JR.

PHILADELPHIA, *November* 26, 1877.

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### "FLORIDA LIZARDS."

*To the Editor of the Popular Science Monthly.*

DEAR SIR: In corroboration of Mr. Gillman's statements regarding the change of color or "chameleonization" of the Florida lizard (the species of which I presume to be *Anolis principalis*), and which is noticed in the December number of THE POPULAR SCIENCE MONTHLY, permit me to say that, in 1871, while in North Carolina, I had a number of these lizards in captivity for the purpose of studying and observing their habits, and in 1873 published in the *Rod and Gun* a short paper as the results of my observations, which fully confirm those made by Mr. Gillman, as the following extract will show: ". . . The first peculiarity noticed about them was their change of color; before retiring for the night a sheet of paper was thrown over the box, and removed the next morning. To my amazement my pets, that had been a vivid green color the day before, were now of a dirty-brown tint, and extremely sluggish in their movements; but, to my great delight, so soon as the rays of the sun fell upon them, the green returned, and they became as lively as ever. This change of color is very curious and peculiar, taking place under a variety of circumstances. For instance, after burrowing in the sods (with which their box was lined) on their return to the light they would at first be brown, but recovered their normal tints shortly afterward. When asleep the green color would frequently be replaced by brown, and, still more curious, if during the day the sun for any length of time was obscured by clouds, the same effect was produced. The manner in which the green tint replaced the brown was very interesting. In some instances a little patch of green would appear on the end of the snout, others would appear in different portions of the body; these would extend and gradually coalesce until the whole body had resumed its usual tint." During the procreative act, there was an ever-varying change of color from the most vivid green to dull, dusky brown. During anger, and while feeding, these changes were very noticeable. I have never seen the colors change so rapidly as Mr. Gillman states, but this may be due to the fact that his observations were made upon individuals free and unrestrained of their personal liberty, mine upon captives.

Respectfully yours,

H. C. YARROW.

SMITHSONIAN INSTITUTION, WASHINGTON, D. C., *November* 20, 1877.

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## EDITOR'S TABLE.

### *THE DOCTORING OF DARWIN.*

THE University of Cambridge, with much *éclat*, recently conferred the degree of L.L. D. upon Mr. Charles Darwin. This circumstance has elicited much diversity of comment on the part of the press. Some maintain that the conferring of this honor is to be construed as a virtual indorsement of the doctrines that are associated with the name of this eminent naturalist; and they regard the action of the university as a triumph of the advanced biological school over the clerical and conservative party by which the university has been hitherto dominated. Others maintain that the proceeding is susceptible of no such interpretation, but that the degree was awarded simply in recognition of the important services of

Mr. Darwin in the general field of natural history, regardless of those peculiar doctrines which have become identified with his name. There is probably truth in both views sufficient to make out a case. It is not to be denied that Mr. Darwin has done a great deal of valuable original scientific work as an observer that has enriched biological science, quite independent of the hypothesis that he has contributed so much to elucidate. But, on the other hand, it is pretty certain that, notwithstanding the extent of these merits and claims, Cambridge would not have spontaneously honored a man who has come to be the representative of all that is most obnoxious in the inexorable advance of modern science, unless his friends had vigorously bestirred themselves to secure the result; and from this point of view the action of the institution may be fairly looked upon as a victory of liberal ideas over the traditional narrowness, prejudice, and intolerance, which rule in the great seats of English learning. For, if Cambridge meant merely to grant its honor to a distinguished man of science, the question arises, "Why has she not done it long before?" Mr. Darwin's labors were widely known and thoroughly appreciated by the highest scientific bodies. He began his career as a naturalist at the age of twenty-two by joining the expedition of the Beagle, which went on a four years' exploring tour around the world. While absent and at the age of twenty-five, he was elected a Fellow of the Royal Society, and he contributed an elaborate volume narrating his discoveries in natural history and geology, which was issued upon his return, and separately republished in 1845. Other important works followed; in 1853 the Royal Society awarded to him the Royal Medal, and in 1859 he received the Wollaston Medal from the Geological Society. The matured results of all his natural history studies were embodied in a volume on "The Origin of Species," published in the same year. Aside from any question of the truth of the hypothesis there presented, or any question as to the exclusiveness of Mr. Darwin's claims in originating it, there can be no doubt that this book has proved one of the most powerful provocatives of inquiry that have appeared in modern times. If, therefore, Cambridge had been animated with a true spirit of liberal scholarship, it is impossible to see why she did not accord the doctorial honor to Mr. Darwin fifteen or twenty years ago.

It would seem that the current notion that these great schools are influenced by just and generous ideals in the bestowment of their honorary degrees is very much of an illusion. They exhibit little alacrity in detecting merit, and signalizing talent in its early and decisive displays, when their recognition would be of some service to the recipient. They wait until they get more than they give by the transaction. When a man of intellectual power has fought his way to fame, and become indifferent to factitious honors, or when a man of force has won some notoriety that makes him conspicuous, so that everybody is watching and talking about him, the universities are then ready enough to avail themselves of the advantages that may arise from their association with his name. Cambridge was probably reluctant in this particular case, as its short-sighted authorities probably thought that they might lose more than they should gain by crowning Darwin with the doctorate; but, as remarked by the editor of *Nature*, the university seemed conscious of the honor Mr. Darwin was conferring upon it, and the enthusiasm of the performance will no doubt satisfy the authorities that they have done a good stroke of business, as coming generations will assuredly view the matter in a very different light from the way it has been viewed in the past.

### THE SUN-SPOTS AND THEIR EFFECTS.

THE phenomena of sun-spots are now familiar: multitudes of people have seen them, and everybody has read about them. It is well known that the surface of the sun is not that uniform disk of light that it was formerly supposed to be, but abounds in gulfs, dark chasms, up-rushing streams of flaming gases, and lurid prominences, sometimes 100,000 miles high. But these striking effects are not uniform: the sea of solar fire, like our own oceans, is sometimes violently agitated and sometimes quiet. The spots are variable, being now many and enormous in size, and again few and small. This periodicity, moreover, is proved to be regular. Prof. Schwabe, of Dessau, discovered that, instead of being uniform in number and intensity from year to year, spots increase and decline at definite rates for a term of years. As a result of 9,000 observations, during which he discovered 4,700 groups, he traced three complete oscillations from maximum to minimum, which he estimated to take place in about ten years. Prof. Wolf, of Zurich, went into an exhaustive history of the subject, and, by collating a vast number of observations and records from 1750 to 1860, he verified Schwabe's general results, but showed that the period of oscillation is about eleven years. His data, scattered through a course of 140 years, comprehended observations in the seventeeth century made on 2,113 days; in the eighteenth century, on 5,490 days; and in the nineteenth century, on 14,860 days, or a total of 22,463 days. On this broad basis of observation, made with no reference to any hypothesis of variation, it is established that the solar energy changes in intensity by a regular law of rise and fall from a maximum to a minimum of effect; and that the maximum, or greatest activity, coincides with the period of violent perturbation when there is the greatest number of eruptions of heated matter from below, and the most conspicuous display of sun-spots and prominences; while at the minimum periods these manifestations are greatly reduced, or almost entirely wanting.

It is now an admitted fact of science that the earth is dependent upon the sun for the chief portion of the energy by which terrestrial effects are produced. With the exception of the ebb and flow of the tides, all the forms of earthly power are recognized as having, directly or indirectly, a solar origin. Wind-power, water-power, steam-power, the activities of organic growth, all animal energy, and the great phenomena of changes in the crust of the globe, due to the circulation of waters through atmospheric agency, are caused by the forces of solar radiation. But if the solar energy is variable, the question naturally arises, "Is that variation manifested in terrestrial effects, and, if so, in what manner, and to what extent?" The subject is vast and new, but the indomitable energy of modern scientific inquiry has rapidly accumulated evidence which answers the first question in the affirmative, and gives instructive replies to the others. The sun-spots, for thousands of years unknown, and for centuries after they were known regarded as mere matters of curious and idle speculation, are now linked indissolubly to the whole scheme of activity which we observe upon earth, and of which we are ourselves a part. Even the famines by which nations are periodically desolated seem to be connected with this intermittence of solar energy. The evidence upon the subject has been summed up in an able and impressive paper contributed by Messrs. Lockyer and Hunter to *The Nineteenth Century*, and which will be found in full in No. VIII. of THE POPULAR SCIENCE SUPPLEMENT. We can here do little more than indicate the remarkable con-

nections that have been disclosed between the variations of solar activity and resulting terrestrial phenomena:

1. The first coincidence observed was in the field of terrestrial magnetism. "A freely-suspended magnet, although it points in one direction, is nevertheless, within small limits, always in motion. Certain of these motions depend, as is well known, upon the hour of the day; but the magnet is also liable to irregular, abrupt fluctuations, which cannot be connected with the diurnal oscillations. While Hofrath Schwabe was engaged in delineating the sun-spots, Sir Edward Sabine was conducting a series of observations with regard to these spasmodic affections of the needle, and he found that such fluctuations are most frequent in years of high sun-spot activity." Nearly a hundred years ago, Van Swinden had suggested a periodicity in these irregular magnetic movements. Gauss, Arago, Lamont, and Gautier, pursued the research, and established the existence of a cycle of magnetic variation having an eleven-year period, the maxima and minima agreeing with the maxima and minima of sun-spot activity. Schiaparelli and Broun have confirmed these results, and the latter observer concludes that, while the sun-spot activity is not an exact measure of magnetic action, "each is a distinct result due to the same cause." This disturbance is so great that, in years of maximum sun-spots, the working of the telegraph has been powerfully interfered with.

2. Connected with these effects there have been observed corresponding disturbances of electrical activity. A magnetic storm never rages without various accompanying signs of electrical excitement. These are seen in auroral displays that in their varying intensities conform to the magnetic cycles. Prof. Loomis, of Yale College, after a critical study of the subject, "concluded that the auroras observed in Europe and America exhibit a true periodicity closely following the magnetic periods, but not perfectly identical with them;" and Mr. Charles V. Walker, telegraphic superintendent, holds as an established fact that "earth-currents, disturbed magnetometers, and aurora, are parts of the same phenomenon."

3. There is evidence of thermometric variations, or fluctuations of temperature, in periods coinciding with the sun-spot cycles. The observations in this case are, however, much complicated and obscured by the agency of the atmosphere, which acts as a screen upon the earth's surface, disturbing the radiations that would affect our thermometers. But a large number of observers, among whom are Baxendell, Blandford, Stewart, Roscoe, Piazzi Smyth, Stone, and Köppen, have accumulated numerous observations both in the temperate zones and in the tropics, showing that "the calorific intensity of the sun's rays is subject to periodical changes, the maxima and minima of which correspond respectively with those of sun-spot frequency."

4. The wind-disturbances of the earth's atmosphere follow the same law; there being a coincidence between the frequency of cyclones and sun-spots. Observations on opposite sides of the world, and in the tropics where wind-disturbances are most violent, lead to the conclusion, as stated by Mr. Meldrum, that "the whole question of cyclones is a question of solar activity; and that, if we write down in one column the number of cyclones in any given year, there will be a strict relation between them—many sun-spots, many hurricanes; few sun-spots, few hurricanes."

5. Confirmatory evidence of this is found in the records of shipping-disasters. From the returns of marine casualties posted on Lloyd's loss-book it was found that they disclose "a cycle closely corresponding with the sun-spot period. The percentage of casualties on

the registered vessels of the United Kingdom (Great Britain) was 17½ per cent. greater during the maximum two years in the common cycle than during the minimum two years."

6. It has been further shown by the observations of Baxendell, Meldrum, Rawson, Jelinck, Wex, Dawson, Hennessey, Broun, and Brockelsby, that there is a fluctuation in the fall of rain in which the same law may be traced; that is, "a connection between the variations of the sun-spot area and the annual rainfall; the rainfall rising above the mean when the sun-spot area is in excess, and falling below the mean when in periods of small sun-spots." The monsoons are the great sources of rain-supply at Madras, in India. The rainfall cycle has been traced out in that country, and the deficiency and excess of rain connected with the great solar periodicities. The writers whom we are following say, for example, that "the water-supply brought to Madras by the southern monsoon is 26½ per cent. greater in ordinary years than in the years of minimum sun-spots." And again, "there is a rain-cycle of eleven years at Madras which coincides with the cycle of sun-spots; the periods of maxima and minima in these two cycles disclosing a striking coincidence."

7. The variation in the rainfall of India involves the food-supply of that country, and is a question of famine and starvation. Observations on the variation of water-supply, in India, of course go no further back than the introduction of rain-gauges. Commencing the inquiry in the year 1810, Messrs. Lockyer and Hunter say: "The years of famine in Madras since that date have been 1811, 1824, 1833, 1854, 1866, and 1877. These famines were caused by deficient rainfall in the preceding years, namely, in 1810, 1823, 1832, 1853, 1865, and 1876. Now, five out of these six years of drought fell within the three years' group of minimum rainfall and sun-spots (shown in the foregoing tables); the remaining drought (1853–'55) extended over a year immediately preceding the minimum group, and two years within that group; the famine itself resulting within the minimum group. Three of the six years of drought fell exactly in years of minimum sun-spots; one fell in the year preceding a year of minimum sun-spots; one fell in the second year preceding a year of minimum sun-spots; the remaining drought, 1853–'55, fell in the first, second, and third years preceding a year of minimum sun-spots. . . . No famine in Madras has been recorded from 1810 to 1877, caused by a drought lying entirely outside the minimum group of sun-spots and rainfall."

We have here been able only to hint at the points made in the paper referred to. The case is strong, in fact much of it demonstrative, yet it is, of course, most incomplete. Though important practical conclusions have been reached, the investigation is in its crude, preliminary stage, where the truth is caught vaguely and by glimpses rather than seen clearly and by a steady gaze. Yet it is a magnificent research, with already-assured results and a splendid promise. We commend the subject to the consideration of those who hold that science, to be genuine, must have become exact, certain, and perfect.

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### *THE SCIENCE OF SOCIETY.*

We have taken the ground in this periodical, and we abide by it, that the most important of all subjects for general consideration, and especially for the American people, is the application of science to questions of society and government. When the Monthly started, we obtained from the foremost thinker of our times in this growing department of inquiry a series of papers, in popular form, designed to present the character and claims, difficulties, limits, and expectations, of a true social science, so as to fix public attention

upon the subject, and prepare for the more systematic consideration of its principles. The result was those able articles on "The Study of Sociology," by Herbert Spencer, which appeared in our pages, and which, collected in a volume, have been subsequently translated into nearly all the languages of Europe. The subject is one of rapidly-increasing interest, to which this book has in no small measure contributed; and we have now the pleasure of announcing another arrangement with the same author, of equal significance and promise, in the popular exposition of social science.

Of Mr. Spencer's present unrivaled position as the elucidator of the laws of man's social progress there is no longer a question. He was the first to grasp the subject in its full breadth, the first to trace out the completeness of its dependence upon the sciences, and the first to carry his system of thought into practical execution. When he began to publish methodically upon this topic seventeen years ago, his project was regarded as a hopeless chimera; but the work has steadily gained upon public confidence, until its successive volumes have been all reproduced in the leading civilized countries. The interest in the subject is, indeed, now so strong and so general that Mr. Spencer has been urgently called upon to publish in future in such a manner as to bring his views more promptly and generally before the reading world. To this he has so far consented that we shall be able, jointly with the English and Continental periodicals, to represent for a considerable time the advancement of his sociological work.

The volume of "The Principles of Sociology," just published, deals with the primordial conditions of the subject, and with the genesis of those early ideas and feelings which give origin to primary social cohesions and groupings. The next volume is to treat of the evolution of the various forms of government by which society is ruled—Ceremonial, Political, Ecclesiastical. We shall publish next month the introductory essay on Ceremonial Government, its nature, extent, and relation to other forms of control. This will be followed by papers dealing with the various elements and divisions of the subject, such as "Trophies," "Mutilations," "Presents," "Obeisances," "Forms of Address," "Titles," "Badges and Costumes," "Further Class Distinctions," "Fashion," and the "Past and Future of Ceremony."

It need hardly be said that these articles will be in a high degree original and instructive, and will throw an important light upon the historic unfolding of one of the largest divisions of social regulation. They will be invaluable to all who care to understand the agencies by which human conduct is controlled, and the modifications which those agencies undergo in social development. We ask our readers to bear in mind that THE POPULAR SCIENCE MONTHLY is the only magazine in the United States which tries to keep its patrons informed of the advances in this great field of thought; and we earnestly appeal to them to do their share in helping us, by forming clubs among their friends and in their neighborhoods that shall extend the circulation of the MONTHLY. We are trying to do a work of education which our colleges and our periodicals grossly neglect; and our power of accomplishment must depend upon the vigor and liberality with which we are sustained by those who appreciate the importance of the labor.

## LITERARY NOTICES.

THE METHODS OF ETHICS. By HENRY SIDGWICK, M. A. Second edition. Macmillan & Co., London. Pp. 469. Price, $4.

THIS work, which upon its first appearance made a strong impression upon philosophical minds, has passed to a second edition, with numerous alterations and additions; the main part of which, as the author

says, are of an explanatory and supplementary nature. The improvements are here manifest, and we cordially testify that the second edition is much less intricate and obscure in statement than the first. It will be remembered, by those who happen to have read it, that the book is rather critical in character, and is devoted to an examination of the grounds and sufficiency of existing ethical methods, rather than to the propounding of any new system. From this circumstance, together with the infelicity of statement which so marked the first edition, there was often much perplexity to know what Sidgwick himself believed, and what he was driving at. In the preface to the second edition, the author refers to the character of his new matter, and indicates various points in which his views have been modified under the influence of the critical attention his volume has received. One thing is somewhat significant: Mr. Sidgwick is a man given to highly-abstract studies, and he therefore occupies a province that has been thus far least affected by the progress of physical and biological science. He heard a great din in an adjacent field about evolution, but as it did not seem to affect him, he paid little attention to it. When, however, the claim was made that ethics, like almost everything else in this world, must be influenced by evolutionary doctrine, he put in a mild but decisive protest; and in an article in *Mind* maintained, virtually, that it makes no difference as to the present exposition of ethical science how its phenomena came about. In the new edition, however, this judgment is modified. In the preface he says, "I have further been led, through study of the theory of evolution and its application to practice, to attach somewhat more importance to this theory than I had previously done;" to which we mayadd that, in his still further study of that theory, he will attach still more importance to it. Possibly, indeed, his views may become so much more evolved that he will wonder how he could at first have treated the subject with so little reference to that doctrine. If ethics refers to the obligations of conduct, and if the American eagle and the American citizen are not required to conform to the same standard—if organization comes into the question, and man himself, in his organic and racial modifications, illustrates the same principle—then may it become a prime question in ethics as to the right and wrong of conduct in different stages of social unfolding. Should it in fact turn out that the factor which Mr. Sidgwick at first excluded from ethical inquiry, becomes, at length, its dominant factor, it will be but another illustration of that inversion of values of which we have already so many examples in the history of progressive thought.

ISIS UNVEILED: A MASTER-KEY TO THE MYSTERIES OF ANCIENT AND MODERN SCIENCE AND THEOLOGY. By H. P. BLAVATSKY. New York: J. W. Bouton, 1877. Two volumes. Pp. 1365. Price, $7.50.

AFTER a patient examination of these massive volumes, we confess our inability to find what it is that is "unveiled." The dominant aim of the work seems to be to establish the identity between ancient magic and modern spiritualism, and to show that here alone is the ground of a possible compromise in the contest between religion and science. It is but fair to say that the author declines to be considered an ordinary spiritualist, which is certainly creditable to her, but we must refer those who are curious to know in what manner she differs from them to the book itself, with the hope that they will be more successful than we have been. The first volume professes to be devoted to science, and the second to theology; and, in dealing with science, much space is given to the refutation of the idea that it is infallible. When that assumption is set up, this part of the author's effort will become pertinent, and will be, no doubt, appreciated. Scientific men are scolded by her, in a copious variety of diction, because they will not "investigate" the spiritualistic hypothesis. This is quite in the vein of the ordinary spiritualist, and is far from new. When the so-called spiritualist's hypothesis is offered for investigation on the same terms and conditions as the other problems of Nature, there will be no difficulty in getting it investigated. Two or three things are essential to a legitimate scientific hypothesis: It must be expressed in intelligible terms; it must present a definite subject-matter for solution or determination; and it must be one by which predictions can

be made that can be proved or disproved by experiment. In regard to the phenomena, or the alleged facts, the whole question hinges, of course, upon the character of evidence; but here we must say that the author of "Isis Unveiled" shows not the slightest discrimination. There is displayed a great familiarity with magic lore, and a deal of industry in getting together a vast medley of materials. Bible-stories, legends from all lands, from all times, ancient and modern accounts of witchcraft, newspaper reports of table-turning, mind-reading, levitation, the psychological vagaries of a novelist, like Bulwer, and the results of scientific research, are all raked together promiscuously and accorded equal weight. There is no attempt toward a systematic arrangement of these multitudinous materials, nor are they held together by anything deserving the name of reasoning or argument. We are reminded by the book of nothing so much as the rush of *débris* which passes through a sewer after a summer shower. Everything is washed along—garbage, remnants of things once valuable, with now and then something that might be of real worth if sifted out—and the whole borne on by a turbid watery medium which takes its quality from the dirt it carries.

We should say that the work evinces great reading in certain directions, much ill-digested learning, a curious credulity in these times, and a strong tendency to mysticism. It is sure to find readers, as it deals with questions which interest all, and in a manner that will be satisfactory to many. Unhappily, education has not been carried far enough to teach the people to distinguish between the valuable and the worthless among things printed, and we have no doubt there are many who have gone through college and acquired nothing that will protect them from accepting "Isis Unveiled" as pretty fair gospel for these days. We may add that, aside from the uses for which the author designs them, there is a large amount of curious information, facts, and opinions, in her volumes which will be interesting to many, and are elsewhere inaccessible to ordinary readers.

BULLETINS OF THE U. S. ENTOMOLOGICAL COMMISSION. Nos. 1 and 2. Washington, 1877.

THESE pamphlets are issued under the auspices of the U. S. Geological Survey, and are designed to contain such special information of interest or importance in connection with the objects of the commission as may from time to time seem useful. The first bulletin was published in April, and gave instruction as to the destroying of the young insects, which should be done throughout the West during April, May, and June. Number 2 is filled with the natural history of the locust. It is a good compendium of the habits of the pest, and is illustrated by woodcuts and a map. Prof. C. V. Riley is presumably the writer of both numbers.

OUTLINES OF MODERN CHEMISTRY, ORGANIC, BASED IN PART UPON RICHES' MANUEL DE CHIMIE. By C. GILBERT WHEELER, Professor of Chemistry in the University of Chicago. A. S. Barnes & Co., New York. Pp. 231. Price, $1.75.

THIS is a practical work, and has been prepared with especial reference to the requirements of medical students. The author remarks that it would have been easier to compile a larger book, from the bewildering wealth of results afforded by the labors in this branch of science, but he has preferred to prepare a concise and perspicuous outline of the subject, designed to follow some previous work on inorganic chemistry. The book is very neat in form; parenthetical references are given to authorities and original papers; pains are taken to give due prominence to the researches of American chemists; and the volume is supplemented by a careful and copious index.

THROUGH ROME ON: A MEMOIR OF CHRISTIAN AND EXTRA-CHRISTIAN EXPERIENCE. By NATHANIEL RAMSAY WATERS. New York: Charles P. Somerby. Pp. 452. Price, $1.75.

BY ROME, the author here means the Roman Catholic form of Christianity. He early migrated out of Protestantism, and, having settled for a while in Catholicism, moved out into the region of religious doubt and denial, where he claims that he first found true peace. The book is a sort of theological autobiography, in which he visibly and forcibly delineates his mental experiences as a Protestant, a Catholic, and a skeptic. It is earnest in spirit, keenly controversial, and contains many views which

mark the author as a man of reflection and originality.

THE WORLD'S PROGRESS: A DICTIONARY OF DATES; BEING A CHRONOLOGICAL AND ALPHABETICAL RECORD OF ALL ESSENTIAL FACTS IN THE PROGRESS OF SOCIETY, FROM THE CREATION OF THE WORLD TO THE PRESENT TIME. With a Chart. Edited by GEORGE P. PUTNAM, A. M. Revised and continued to August, 1877, by F. B. PERKINS. New York: G. P. Putnam's Sons. Pp. 1020. Price, $4.50.

THIS old and standard book of reference has been revised, brought up to time, and is now reported as in its twenty-first edition. It contains a great amount of information, and, when the method of it is understood, it is conveniently available for use; but it may be observed that if the world's progress had taken place in accordance with the plan of this work, it would have been a somewhat mixed and chaotic affair. The chronological tables conform to the idea of historical progression, but the main body of the book consists of Hayden's "Dictionary of Dates," in which the events of the world are represented, not in the order of time, succession, and causality, but in the alphabetical order, and to this the progress of things has fortunately not conformed.

HISTORY OF THE OTTOMAN TURKS FROM THE BEGINNING OF THEIR EMPIRE TO THE PRESENT TIME. By Sir EDWARD S. CREASY, M. A., late Chief-Justice of Ceylon. First American edition, from the new revised English edition. New York: Henry Holt & Co. Pp. 558.

THE interest of the Eastern question in England has risen to such a point as greatly to stimulate the demand for works relating to the countries now implicated in war. Sir Edward Creasy has thus been led to revise and republish his history of the Turks, which has been long out of print, and Mr. Holt has done a good service to American literature in adding the book to his valuable series on the Oriental countries. The reputation of its author is a guarantee of its excellence, and in making the book over he seems to have spared no pains in the consultation of all authentic sources of information. Judge Creasy says, in his preface, that the most important historical work on the Turks is by the German Von Hammer, who has dealt with the subject so exhaustively that his history, if translated, would make at least twenty English octavo volumes. He has followed this author closely in the reconstruction of his own work, and he speaks of the German treatise to which he is so much indebted in the following terms:

"Von Hammer's 'History of the Ottoman Empire' will always be the standard European book on this subject. The history was the result of the labors of thirty years, during which Von Hammer explored, in addition to the authorities which his predecessors had made use of, the numerous works of the Turkish and other Oriental writers on the Ottoman history, and other rich sources of intelligence which are to be found in the archives of Venice, Austria, and other states that have been involved in relations of hostility or amity with the Sublime Porte. Von Hammer's long residence in the East, and his familiarity with the institutions and habits as well as with the language and the literature of the Turks, give an additional attractiveness and value to his volumes. His learning is as accurate as it is varied; his honesty and candor are unquestioned; and his history is certainly one of the best productions of the first half of our century."

ETHNOGRAPHY AND PHILOLOGY OF THE HIDATSA INDIANS. By WASHINGTON MATTHEWS. Pp. 245. Washington: Government Printing-Office. (No. 7 of "Miscellaneous Publications" of Hayden's Survey.)

THE author of this monograph, while stationed at a military post in Dakota Territory as assistant surgeon, availed himself of the opportunity thus afforded of studying the manners and customs and the language of the neighboring Indian tribe—the Hidatsas or Minnetarees. Among the subjects treated under the head of ethnography are ceremonies, mythology, marriage, relationships, hunting, divisions of time, etc. The philological section is very elaborate, containing a systematic grammar of the language, a pretty full Hidatsa-English dictionary, an English-Hidatsa vocabulary, and a list of local names.

BULLETINS OF THE U. S. GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES. Vol. III., No. 4. Washington, 1877.

THE bulletins of the U. S. Geological Survey, issued by Dr. Hayden to facilitate the publication of the work done by the scientific men of his staff, and to place before

the public speedily the results of his explorations, have now reached the completion of their third volume. The last number is mainly of interest to entomologists, containing an account of the first discovered traces of fossil insects in the American Tertiaries, by Mr. S. H. Scudder. This paper, of 20 pages, is a complete statement of past and present investigations, showing a record of forty-six described fossil species, of which more than half belong to the *Diptera*. Mr. Scudder also describes two species of *Carabidæ* from interglacial deposits near Toronto, C. W. The remaining papers in the number are a description of a new crawfish (*Cambarus Couesi*) from Dakota, by Dr. Thomas H. Streets; and three paleontological papers, by Prof. E. D. Cope, upon reptiles and fishes from Colorado and Wyoming. A very minute index to the whole volume concludes this number.

I. Annual Report of the New York Meteorological Observatory for 1876. By Daniel Draper, Director. Central Park.

II. Report on the Central Park Menagerie, for 1876. New York: by W. A. Conklin, Director.

The first of these handsome pamphlets consists chiefly of tables giving the results of the daily observations at the park, as to the heights of the barometer; force and direction of the wind; rainfall; temperature, etc. The value of a single volume of this kind is very small, but the great importance of such records when extending over a great length of time and a wide area is beginning to be duly appreciated, not only by scientific men, but by the business community generally, being often consulted, Director Draper tells us, for legal and other purposes.

Last year the director was engaged in examining the question, "Has there been in late years any change in the rainfall of New York City, or its vicinity, to affect seriously its water-supply?" His conclusions are, that for a series of years, up to 1869, the rainfall was increasing; "it then showed a tendency to decrease. There are, undoubtedly, cycles of rainfall, as there are cycles in sun-spots and other astronomical phenomena, occupying years for their completion." No predictions are ventured as to the date when the diminution will have reached its minimum and the ascent recommence, the observations being too incomplete for that purpose.

The "Report on the Menagerie" does not show that feature of the park to be in a growing condition. During the year 1876 but nineteen dollars was expended for the purchase of animals, while additions by donation, births, exchanges, and losses, have all fallen off. The number of animals on exhibition at the close of 1876 was: mammals, 184; birds, 394; reptiles, 5: total, 583. The value of those owned by the department is $15,554; owned by exhibitors, $47,390. This result is doubtless due to a reduction in appropriations. It would seem that the menagerie was deserving of a little more fostering care, for that it is a feature which largely interests the public is shown by the great number of visitors, estimated at 3,000,000 for the year.

I. On Some Unexplained Phenomena in the Geyser Basins of the Yellowstone Park.

II. The Two-Ocean Water: The Union of the Atlantic and Pacific Oceans in the Rocky Mountains. By Theodore B. Comstock, B. S.

The object of the first of these papers is to call attention to the importance of improving all opportunities for research, in the region of the National Park on the Yellowstone, concerning the rare phenomena presented by the geysers. These striking features are rapidly waning, and must be studied soon if studied at all.

The "Two-Ocean Water" is, it would seem, a verity, the fact having been established by the expedition of Captain W. F. Jones in 1873. Between Flat Mountain and the Yellowstone Range, and near the headwaters of the Snake and the Upper Yellowstone Rivers, there is a rivulet which was found to divide, "one portion gliding silently into the river behind us, to find its way at last into the Gulf of Mexico, while the other branch descended in front to join the westward-flowing waters of the Columbia, *via* Snake River, finally reaching the Pacific Ocean." The stream bears the name of "Two-Ocean Creek," and its two branches are named respectively Atlantic and Pacific Creeks.

THE AMERICAN PALÆOZOIC FOSSILS: A CATALOGUE OF THE GENERA AND SPECIES, WITH THE NAMES OF AUTHORS, DATES, PLACES OF PUBLICATION, GROUPS OF ROCKS IN WHICH FOUND, AND THE ETYMOLOGY AND SIGNIFICATION OF THE WORDS, AND AN INTRODUCTION DEVOTED TO THE STRATIGRAPHICAL GEOLOGY OF THE PALÆOZOIC ROCKS. By S. A. MILLER. Cincinnati, Ohio: The Author, No. 8 W. Third Street, 1877. Pp. 253.

WE give this long title in full, as it explains in as few words as possible the scope and contents of a very useful book. It is a check-list of American Palæozoic fossils, but it is something more; and the added features are those which will make it specially welcome to students and amateurs who do not have access to large libraries and collections.

The labor of collecting and arranging the materials for such a work is very great, and will, we hope, be appreciated sufficiently to reward the author in some degree for his painstaking zeal.

A paper on the "Construction of Systematic Names in Paleontology," by Prof. E. W. Claypole, forms an important part of the book.

SERPENT AND SIVA WORSHIP. By HYDE CLARK, M. A. I., and C. S. WAKE, M. A. I. Edited by ALEXANDER WILDER, M. D. New York: J. W. Bouton. Pp. 48. Price, 50 cents.

THESE papers, reprinted from the *Journal of the Anthropological Institute of Great Britain*, are examinations into the nature of the worship of the serpent, with a view to tracing its origin and connections, and are important as contributions to the material from which alone a philosophical theory of sociology can be formulated. The facts cited confirm Mr. Spencer's conclusions as to the intimate relations between ophiolatry and ancestor-worship.

ON A SCIENTIFIC COURSE OF STUDY. A Paper read before the State Teachers' Association of Iowa, by Prof. C. E. BESSEY. Pp. 11.

THIS seems to be in some measure an effort to reconcile the antagonism between the languages and science as means of culture.

The author is not disposed to underrate the importance of the sciences, and makes some excellent remarks as to the methods of teaching them to the young; the necessity of beginning the science-teaching early; and also as to the value of the languages as tools for the scientific man. But he seems to miss the real question at issue in the "conflict." It is not "What kind of training is best to produce a scientific specialist?" but "What are the relative claims of the study of language and of natural science in giving the discipline and culture which will be useful in the ordinary walks of life?" Upon this point we would refer Prof. Bessey to Prof. Bain's article on "Language-Culture and the Civil Service," in the December number of THE POPULAR SCIENCE MONTHLY.

I. PROCEEDINGS OF THE DAVENPORT ACADEMY OF NATURAL SCIENCES. Vol. II., Part 1. Davenport, Iowa. Pp. 148. Price, $3.

II. PROCEEDINGS OF THE BOSTON SOCIETY OF NATURAL HISTORY. Vol. XVIII., Part 4. Boston. Pp. 104.

THE first of the above volumes is largely taken up with records of the business meetings of the Davenport Academy, its condition, etc., interspersed with some papers of interest. The majority of these are archæological, being descriptive of mounds and their contents, illustrated by several fine photographic plates of inscribed tablets. Iowa is rich in these relics of the mound-builders, and there is a fitness in the Academy devoting itself to a study of these remains, which are fast disappearing.

The Boston "Proceedings" is filled with the results of more steady-going, thorough work, as might be expected from its greater age, and its locality in a centre where scientific men congregate. The table of contents includes papers on "The Origin of the Domestic Sheep," by G. W. Bond; "Genetic Relations of Stephanoceras," by Prof. A. Hyatt; "Reptiles and Batrachians from the Isthmus of Panama," by S. W. Garman; "Notes on Noctuæ from Florida," by A. R. Grote.

NINTH ANNUAL REPORT ON THE NOXIOUS, BENEFICIAL, AND OTHER INSECTS OF THE STATE OF MISSOURI. By CHARLES V. RILEY, State Entomologist. Jefferson City, 1877. Pp. 130.

THIS continuation of Prof. Riley's labors in the field in which he has become so well known covers observations on the currant,

gooseberry, strawberry, and pine worms; the army-worm, Colorado potato-beetle, Rocky Mountain locust, etc.; together with the insects which, acting as parasites, help to diminish the number of these pests.

The illustrations are numerous, drawn mostly by the author from Nature; the suggestions are practical, and make the reports valuable to the agriculturist as well as to the scientific entomologist. The locust, or so-called grasshopper, naturally receives the fullest attention, and certainly the facilities for observation have been ample enough for the accumulation of information that will be of use, should the West be again visited by that scourge.

SAVINGS-BANKS. A Paper read before the American Social Science Association, September 5, 1877. By JOHN P. TOWNSEND. New York, 1877.

THIS, as might be expected from the long experience of the author, is a valuable addition to savings-banks literature.

In the history of the rise and progress—we had almost said decline—of the system; the criticism of past and present management; and the suggestions as to the proper way to run such institutions, a thorough familiarity with the subject is shown. The remarks on the nature of investments are to be commended to presidents and trustees, and the plan for winding up insolvent institutions would, if adopted, do much to mitigate the loss and suffering which the present mode of procedure involves.

Some space is given to the details of a plan for school penny savings-banks, which is simple and perfectly practicable, having been found to work well both in England and on the Continent, cultivating habits of thrift in the young, and exercising an excellent influence in the communities where they have been started.

EGYPT AS IT IS. By J. C. MCCOAN. New York: Henry Holt & Co., 1877. Pp. 417. Price, $3.75.

THE task which Mr. McCoan has undertaken is, to describe and explain the economic conditions of the New Egypt, as will appear from the titles of the chapters, which include those on the territory, population, administration, finance, commerce, agriculture, public instruction, public works, manufactures, etc., with a series of appendices giving statistical information about the government, finances, trade, cost of living, etc.

The author says that he found this corner of the field of book-making on Egypt almost untouched. No material lay ready to his hand, but his facilities for getting it were good, and he has made excellent use of them. The Government of Egypt is the khedive. Legislative bodies, ministers, and cabinets, are mere agents of his personal will, and the recent progress is due mainly to his wisdom and energy. His highness is now forty-six years old, below the middle height, stout, though not unwieldy, and with nothing of an Eastern but the native dignity and easy polish of his manners. He devotes fourteen hours a day for at least three hundred days in the year to the work of administration, is familiar with all the details of national affairs, and in the extent and variety of his information is as encyclopedic as Dom Pedro himself.

The book corrects some common misapprehensions. Taxation of the peasantry, for example, though heavy, is not so oppressive nor enforced so brutally as we have been given to understand; and the system of slavery, though in itself indefensible, is not at all such as formerly obtained in the United States, and still exists in Cuba and Brazil. In both these respects the condition of Egypt is vastly better than that of the nominally ruling country, Turkey. An excellent map and a copious index add to the value of the book.

HEREDITY: ITS INFLUENCE UPON THE PROGRESS AND WELFARE OF MANKIND. By E. N. BRUSH, M. D. Buffalo, 1877. Pp. 12.

HEREDITY AS A FACTOR IN PAUPERISM AND CRIME. By E. H. PARKER, A. M., M. D. Poughkeepsie, N. Y., 1877. Pp. 12.

CRIMINALITY. By W. G. STEVENSON, M. D. Poughkeepsie, N. Y., 1877. Pp. 23.

THESE pamphlets are all reprints of papers read before medical societies, and have a common object, which is to show the importance of heredity in fixing the organic characteristics of the individual, and so determining the part which he shall play in society—characteristics which are, of course, modified to a greater or less extent by the environment. They are chiefly inter-

esting as showing how wide is the recognition that is being accorded to the important labors of Mr. Darwin and his co-workers.

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PUBLICATIONS RECEIVED.

Proteus; or, Unity in Nature. By C. B. Radcliffe, M. D. London and New York: Macmillan. Pp. 222. $2.50.

Deed and Creed. By Dr. Felix Adler. New York: Putnam's Sons. Pp. 248. $1.50.

Determination of Rocks. By E. Jannetaz. New York: Van Nostrand. Pp. 165. $1.50.

Creed of Christendom. By W. R. Greg. Boston: Osgood & Co. 2 vols. $7.

Report of the Nashville Board of Health. Pp. 230.

Biology. By J. Cook. Boston: Osgood & Co. Pp. 337. $1.50.

The Signal Boys. By G. C. Eggleston. New York: Putnam's Sons. Pp. 218.

Doubleday's Children. By D. Cook. New York: Putnam's Sons. Pp. 430.

Myths and Marvels of Astronomy. By R. A. Proctor. New York: Putnam's Sons. Pp. 371. $4.

Report of the Commissioners of Agriculture (1876). Washington: Government Printing-Office. Pp. 447.

Methods of Ethics. By H. Sidgwick. London and New York: Macmillan. Pp. 497. $4.

Geology of Wisconsin. By T. C. Chamberlin, Chief Geologist. Vol. II. Pp. 787. With Atlas.

Vital Magnetism. By F. T. Parson. New York: Adams, Victor & Co. Pp. 235. $1.25.

At the Court of King Edwin. By W. Leighton, Jr. Philadelphia: J. B. Lippincott & Co. Pp. 127. $1.25.

The Electric Register. By Le R. C. Cooley. From the *Journal of the Franklin Institute*. Pp. 5.

The Convection Thermoscope for Projection. By Le R. C. Cooley. Pp. 4.

Five Entomological Papers. By C. V. Riley, Ph. D. From "Transactions of the St. Louis Academy of Sciences." Pp. 34.

Functional Dystocia. By Dr. E. M. Hale. Pp. 26.

Birds of Connecticut. By C. H. Merriam. From "Transactions of the Connecticut Academy." Pp. 165.

Circular of Bureau of Education. Washington: Government Printing-Office. Pp. 28.

Transactions of the Kansas Academy of Science. Topeka: G. W. Martin. Pp. 75.

Contributions from the Chemical Laboratory of Harvard College. By J. P. Cooke, Jr. Pp. 181. With Plates.

Admission of Girls to the Boston Latin School. By President Warren. Pp. 8.

Why Scientists are not Christians. By E. A. Beaman. New York: E. H. Swinney. Pp. 16.

Medical Intolerance. By Dr. R. A. Gunn. New York: Munroe & Metz. Pp. 28.

What Anæsthetic shall we use? By Dr. J. J. Chisolm. Baltimore: *Sun* print. Pp. 23.

Reptiles, Fishes, and Leptocardians of the Bermudas. By G. Brown Goode. From *American Journal of Science*. Pp. 10.

Report of the Philadelphia Water Department (1876). Pp. 125.

List of Writings on Method of Least Squares. By M. Merriman, Ph. D. From "Transactions of the Connecticut Academy." Pp. 82.

American Archæology. By Dr. A. J. Howe. Pp. 8.

Sanitary Condition of Portland. By Dr. F. H. Gerrish. Portland: S. Berry print. Pp. 30.

Illinois State Historical Library. Springfield: D. W. Lusk print. Pp. 7.

Notes on Leather. By Lieutenant D. A. Lyle, U. S. A.

Medical Jurisprudence. By Dr. S. E. Chaillé. From "Transactions of the International Medical Congress." Pp. 40.

Catalogue of Minerals in the Naval Academy Cabinet, Annapolis. Washington: Government Printing-Office. Pp. 21.

Budge and Toddle. By L. G. Morse. New York: Putnam's Sons. Pp. 308.

Syllabus of Lectures in Anatomy and Physiology. By T. B. Stowell. Syracuse, N. Y.: Davis, Bardeen & Co. Pp. 82.

A Layman's Experience in Homœopathy. By W. H. Furness. Pp. 8.

Money and Legal Tender. By H. R. Linderman. New York: Putnam's Sons. Pp. 173. $1.25.

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# POPULAR MISCELLANY.

**Our Current Weights and Measures.**—The absurdities of our present no-system of weights and measures surpass belief: they have their parallel in the absurdities of our present no-system of "orthography," but hardly anywhere else. The question of reducing to rule the current English orthography is now receiving attention, but the prospects of anything being done are gloomy enough. So, too, we hear occasionally of the necessity of reforming our weights and measures, but as yet no real progress has been made in any of the English-speaking countries. Our excellent contemporary, the *Engineering and Mining Journal*, in the course of an article favoring the adoption of the "metrical" system, gives the following apt illustration of the deplorable multiplicity of standard tons now in use:

"In a copper-works ore is measured and paid for by the (tribute) ton of 2,352 pounds, from the mine through the mill, till it comes out of the jigs, when suddenly it is transformed into a ton of 2,240 pounds (the difference, perhaps, going out in the tailings), which is the ton of the roasting and smelting furnaces and of the teamsters. This continues till the copper is sold or carried over some roads, when the ton shrinks again and becomes 2,000 pounds. At the iron-works there are still more tons, different from these, and on the railroads one will report the coal carried in tons of 2,240 pounds, and another connecting road uses

the ton of 2,000 pounds. And in order to maintain the beautiful symmetry of our system, they, of course, rarely, if ever, state what kind of a ton is used in either case. Coal is mined and miners are paid by tons of various weights, from 3,000 pounds to 2,000 pounds. It is sold by tons of 2,240 and 2,000 pounds, and by tons running all the way down to 1,500 pounds. The use of the ton less than 2,000 pounds is called cheating, but the large purchasers, those who buy from a car-load (six tons) up, may get 2,240 pounds to the ton; but, if they buy from the same company's retail yard, they find the ton weighs no more than 2,000 pounds, if it does that. Coal is sold by bushels of 76 pounds and 80 pounds, by barrels, loads, hogsheads, and other 'standards,' the weights of which depend originally on the fancy of the individual, and subsequently on 'immemorial custom.'"

**A Kansas Gas-Well.**—About three years ago a company prospecting for coal discovered at Wyandotte, Kansas, a fountain of combustible gas. This gas, as we learn from the *Western Review of Science and Industry*, is now used by the company for steam-making, and by the owner of the farm where it is located for cooking and illuminating purposes. The gas, whether flowing or burning, is almost odorless, and its entire freedom from sulphur adapts it very well for use in the reduction of gold and silver ores. Notwithstanding a coal-vein of considerable thickness was discovered, the company has concluded to abandon coal-mining for the present, and utilize this new gas-fuel. Nor is the latter adapted for heating purposes alone; it is also very valuable for light, inasmuch as it burns with a clear, bright flame, even without purification, and is free from the disagreeable odor accompanying coal-gas. The city of Wyandotte will soon be lighted by this gas, which, as it comes from the well, is of twelve-candle power. At small cost it can be purified so as to make it sixteen-candle power. The brine ejected from the well by the escaping gas is not strong enough for the manufacture of salt; it is recommended as a medicinal agent for the treatment of sundry diseases. The company contemplate erecting an extensive establishment for mineral baths.

**A Plague of Rats.**—Shortly after the settlement of the Bermudas by the British, the colony was infested with rats, which, in the space of two years, had increased so alarmingly that none of the islands were free from them, and even fish were taken with rats in their bellies. A writer in the *Academy* recalls some of the horrors of this plague of rats. The rats, we are told, had nests in almost every tree, and burrowed in most places in the ground like rabbits. They devoured everything that came in their way—fruits, plants, and even trees. Where corn was sown they would come by troops in the night and scratch it out of the ground; "nay," writes a contemporary chronicler, "they so devoured the fruits of the earth that the people were destitute of bread for a year or two." Every expedient was tried to destroy them. Dogs were trained to hunt them, who would kill a score or more in an hour. Cats, both wild and tame, were employed in large numbers for the same purpose; poisons and traps—every man having to set twelve traps—were brought into requisition; and even woods were set on fire, to help to exterminate them. Every letter written at this period by the plague-stricken colonists contains some account of the dreadful scourge. "Our great enemies the rats threaten the subversion of the plantation," writes one colonist in July, 1616. "Rats are a great judgment of God upon us," wrote another a year later. "At last it pleased God, but by what means is not well known, to take them away, insomuch that the wild cats and many dogs that lived on them were famished." There was universal joy at the sudden removal of such destructive vermin; and the all but despairing planters were enabled once more to resume their neglected occupations with spirit and energy.

**Composition of Pumpkins.**—Analyses of pumpkins, made by Prof. F. H. Storer, of the Bussy Institution, show that the rind of that vegetable is nearly three and a half times as rich in albuminoids as the flesh. The weight of albuminoids in the flesh is only about one-fifth as much as that of the carbohydrates, a proportion that has sometimes been found in turnips. Again, the inside or offal portion (including the seeds)

of the pumpkin contains a large proportion of nitrogen, and the seeds yield a high percentage of oil. "The presence of such large amounts of oil, and of albuminous matters," adds Prof. Storer, in the *Bulletin of the Bussy Institution*, "would naturally go to show that pumpkin-seeds must be a highly-nutritious kind of food; and it may well be true that they are valuable for some kinds of animals, when administered carefully and in moderate quantity. But it has often been urged that the seeds are apt to do harm to animals that have eaten them. . . . There is little question that this idea is to a certain extent founded in fact." The dangers of using the seeds must, however, be both small and remote, since, as the author shows, New England farmers usually feed out the seeds with the flesh; still they should not be fed to milch-cows. Regarding the use of these seeds as articles of human food, the author quotes Pumpelly as saying that the kernels are eaten by the Chinese. In Egypt, too, pumpkin-seeds are eaten in the same way that nuts are eaten in other countries.

**Ancient Man in Japan.**—Prof. E. S. Morse has made an important discovery in the study of ancient man in this part of the world, lighting on evidence of the remains of prehistoric inhabitants of Niphon who apparently must have antedated even the Ainos. The eyes of this distinguished scholar, possessing as they do the rare quality of seeing, observed, while he was on his first trip to the capital from Yokohama, one of those significant shell-heaps which have been found in many countries and prove the high antiquity of the human race. This particular *kjockkenmoedding* is situated near Omori, on the line of the railroad, and is rich in evidence of a rude people that dwelt in Japan at a very early age. Prof. Morse has been engaged for many years in the study of these mounds, as found in Maine, North Carolina, and Florida. This heap, which is about ten feet in thickness at its greatest diameter, under a loam-deposit of six feet, and half a mile from the present shore of the bay, exhibits all the peculiarities of its type, containing bone, both in fragment and rudely fashioned into implements, and characteristic pottery. Some of the earthenware is curious enough, and is thoroughly representative of a development of the race coinciding with that of the ancient savages of America and Europe. The professor has made an exhaustive study of the deposit, and there seems little doubt of its true character. As, however, he has consented to address the Asiatic Society on the subject at its approaching meeting, we will not enlarge more particularly upon it at present, only advising all to avail themselves of the rare opportunity to hear one of the most fascinating of American lecturers on a theme of novel and great local interest.—*Tokio Times.*

**Interesting Ethnological Specimens.**—At a meeting of the Natural History Section of the Long Island Historical Society, Mr. Elias Lewis, of Brooklyn, exhibited several remarkable specimens of smoked Indian heads, brought by Mr. Ernest Morris from the hitherto little known region near the source of the Tapajos River, in Central South America. Some account of these heads was given by Mr. Lewis, and published in the *Brooklyn Eagle*. They are ten in number, and of great ethnological interest. The natives seemed to well understand the art of preserving them, but were exceedingly unwilling that Mr. Morris should get possession of the peculiar wood or root by the smoke of which they are preserved. A piece, however, was obtained and hidden by Mr. Morris in his luggage. The flesh and muscles of the smoked heads are shrunken somewhat, and quite hard, but the features are not distorted, and have a singularly life-like appearance. All the lineaments of the face are clear and well defined. Most of the faces are tattooed. The hair is long, black, and very thick on the scalps, and the red paint with which the natives adorn themselves still remains in the hair of several of the specimens. The heads are ornamented with feathers, strings, and other appendages. In most cases the front teeth are wanting, having been knocked out previous to the smoking. Mr. Morris obtained the heads from the chief or principal man of one of the tribes in exchange for knives and other articles, and brought them away with great difficulty and some risk. In a letter from Mr. Morris it is stated that "the heads are

those of the Parrebeate Indians, better known as the Parrintintins, who inhabit the land of the upper Tapajos. They are mostly taken in war and kept as trophies, and are preserved by smoke from a root which they call *carrocopowpow*. "They are very much as they appear in life, except that a cord is put in the mouth to carry them by, and the eyes are covered with a mass of wax. The practice was current among the Mundurucu tribe long since, but now appears to be practised only among the wild tribes which inhabit the country near the sources of the Tapajos and Hingu Rivers. The heads were taken about two years ago." One of the heads is that of a woman. Mr. Morris is now on his way to the Amazon for further exploration, and a part of the collection is offered for sale in his interest; the rest will be placed in the museum of the Long Island Historical Society.

**A New Japanese Fruit-Tree.**—We have received from Prof. R. H. Wildberger, of the Kentucky Military Institute, some of the fruit of the *Guikgo biloba*. This fruit was matured on a tree growing in the institute grounds, and is supposed to be the first ever produced in the United States. In a communication to the editor, Prof. Wildberger says that the tree is a native of Japan, and has been largely introduced into the United States and Europe, on account of its ornamental appearance. The one in the Military Institute flowered and fruited in June; in September the fruit began to turn yellow, and, after one or two frosts in October, to fall. This tree, which is about thirty feet in height, stands about eighteen feet from another of the same species which bore no fruit. Being absent at the period of flowering, our correspondent was unable to determine whether the species is dicœcious, i. e., bearing pistillate flowers on one tree and staminate on another. Of the fruit he writes that it is a *drupe* or stone-fruit, about the size of a common wild-plum, much resembling it while green; but when mature it has a shriveled appearance, and is yellow in color. The sarcocarp, or fleshy part, is easily separable, disclosing the *putamen*, or stone, which is smooth and thin-walled, containing a kernel as large as a plum-stone, which has a pleasant taste. The sarcocarp has an acid, astringent taste, and a rather fetid odor. The kernel is said to be highly prized in Japan, and to be served at all banquets, being supposed to promote digestion and prevent flatulence.

**New Order of Extinct Reptilia.**—The museum of Yale College lately received the greater portion of a huge reptilian skeleton, found on the eastern flank of the Rocky Mountains, in beds that have been regarded by Prof. Marsh as corresponding nearly to the Wealden of Europe, and which may be classed as Upper Jurassic. Prof. Marsh writes that the remains are well preserved, but imbedded in so hard a matrix that considerable time and labor will be required to prepare them for a full description. The characters already determined point to affinities with the Dinosaurs, Plesiosaurs, and more remotely with the Chelonians, and indicate a new order which may be termed *Stegosauria*. The animal was probably thirty feet long, and aquatic; the body was protected by large bony dermal plates, which appear to have been in part supported by the elongated neural spines of the vertebræ. One of these dermal plates was over three feet in length.

**Origin of the Moral Sense.**—According to Darwin's theory the moral sense, conscience, is a development of the animal instinct of self-preservation. The scope of this instinct was at first confined within the individual; it was next extended to the group of animals in which it lived. In a low stage of human development, man would be bound by the ties of moral obligation at the most to those of his own tribe; but as he advances in civilization, and small tribes are united into larger communities, "the simplest reason," says Darwin, "would tell each individual that he ought to extend his social instincts and sympathies to all the members of the same nation. This point once reached, there is only an artificial barrier to prevent his sympathies extending to the men of all nations and races." Moral sense, in this theory, is an enlargement of an animal instinct, illumined by the light of reason. To many persons this way of accounting for the origin of morality is an abomination; it is supposed that thereby

something is taken from the preëminent dignity of man. The objection is well met by Mr. J. A. Allen, who writes as follows in the *Canadian Monthly:* "I should be satisfied to resign my free-will to do wrong for a nature so constituted that I must always love and do the right. What, by instinct? Yes, by instinct, or by anything else. I should like to be always *instinctively* inclined to good, as the bee to make honey. But if I am denied this—if our nature is not yet adjusted to the requirements of the golden age—it is something to possess an unchangeable instinct of right at the very core of our being, which can neither be plucked out nor enslaved by the will, nor silenced by terror or bribes or flattery. But instinct! How undignified to be forced to do right by compulsion! What? By the compulsion of our own nature, by the imperious and imperial sense of our obligations to our fellow-men? On the contrary, I think that we should be ennobled by the possession of such a moral force." Of the mode in which the principles of morality are propagated Mr. Allen writes: "The maxims of morality, more or less true, come down to us by tradition, and root themselves in our youthful minds; but the solidified moral sense is transmitted by heredity, and forms an integral part of our very selves. It is, so to speak, our experiences, not *from* but *in* our grandfathers; the result stereotyped in our constitutions of all the ictuses of the various forces in this direction which had affected the whole line of our ancestry from the very first—transmitted feelings in transmitted structures."

**The Waste of Wire-Works.**—We are indebted to the *Polytechnic Review* for an account of a process in use at Worcester, Massachusetts, for utilizing the waste of a great wire-working establishment. Formerly the dilute sulphuric acid used for cleaning the wire was allowed to run into the sewer when it had become so charged with iron scale as to cease to "bite," and large quantities of refuse wire were employed only to fill up hollows in grading, or thrown into a heap. All of this waste material is, however, now converted into articles of commercial value by simple and comparatively inexpensive processes. The diluted acid, charged with iron, is heated in lead-lined tanks by means of steam passing through coils of copper pipe, the waste wire being thrown in. In about five days the acid, under the influence of heat, has taken up a large proportion of iron and become liquid sulphate of iron, which is then evaporated until it deposits the crystals known in commerce as copperas. Three tons of this solid sulphate are made per day from about twelve tons of the waste acid. The remaining liquid is returned to the receiving-tank, to be mixed with more of the waste acid and refuse wire; and so the work goes on in a continuous round. Even the waste of this product from waste is utilized. The settlings of the boiling-tank—oxide of iron—together with the waste copperas, an alkali, and an inexpensive substance to give "body," are roasted, ground, and transformed into a pigment equal to imported Venetian red. Of this the company makes about 500 barrels per month.

**Spongy Iron Filters.**—Dr. Gustav Bischof, inventor of the method of purifying water by filtration through spongy iron, recently detailed to the London Royal Society the results of sundry experiments on this and other filtering media. In the experiments fresh meat was placed on the perforated bottom of a stone-ware vessel, which was then filled to about two-thirds with the materials to be experimented upon, and lastly with water, care being taken to prevent the access of bacteria to the meat from any source save the filtered water. In Experiment I., spongy iron was used as the filter: after a fortnight's steady percolation of the water, the meat was fresh. Experiment II. was with animal charcoal: after a fortnight the meat gave signs of incipient putrefaction. Experiment III. was with spongy iron again, the water being allowed to flow for four weeks: the meat was perfectly fresh. In Experiment IV., which reproduced Experiment II., with the exception that the length of time was doubled, the meat was found to be soft and putrid. In the foregoing two experiments with spongy iron, the fine dust of that material had not been separated: in Experiment V. this was done: after four weeks the meat, again, was fresh. To prove that iron in solution was

not in these cases the preserving agent, in Experiment VI. a stone-ware vessel was charged underneath the spongy iron with pyrolusite and sand, so as to abstract the iron from the water before it came in contact with the meat: again the meat was fresh after four weeks' filtration. Experiment VII.: by a separate experiment it had been ascertained by Dr. Bischof that the oxygen is completely abstracted from water during its passage through spongy iron. To determine whether the absence of oxygen is the cause of the preservation of the meat, and whether the bacteria or their germs are killed or can be revived when supplied with oxygen, an evaporating basin was inverted over the meat. Though this must have retained a quantity of air in its cavity, the meat still was found fresh after four weeks. In the final experiment, fresh meat was placed at the bottom of a glass vessel and left standing covered, with about four inches of spongy iron and water. After three weeks the meat was very bad, thus showing that the action of the bacteria of putrefaction adhering to the meat was not prevented by the spongy iron above; and if, during the previous experiments with spongy iron, agencies capable of causing putrefaction had at any time come in contact with the meat—in other words, if the bacteria had not been killed in their passage through the spongy iron—the meat must have shown marks of their action.

The author accounts as follows for the action of this material: "I believe that the action of spongy iron on organic matter largely consists in a reduction of ferric hydrate by organic impurities in water. . . . Ferric hydrate is always found in the upper part of a layer of spongy iron, when water is passed through that material. The ferrous hydrate resulting from the reduction by organic matter may be reoxidized by oxygen dissolved in the water, and thus the two reactions repeat themselves. This would explain why the action of the spongy iron continues so long."

**Marine Fishes in Lake Nicaragua.**—The fish fauna of Lake Nicaragua has long been known to include a few species elsewhere found only in salt-water, as a *Megalops*, a shark, and a sawfish. How did these marine forms first enter the lake? Dr. Theodore Gill and Dr. J. F. Bransford, in a "synopsis" of the fishes of this lake, communicated to the Academy of Natural Sciences of Philadelphia, remark that this combination of species may have resulted—1. From the intrusion of the salt-water types into the fresh waters; or, 2. From the detention and survival of the salt-water fishes in inlets of the sea that have become isolated, and so, in course of time, fresh-water lakes. The latter hypothesis is declared the more probable one. By the uplift of the land an inlet of the Pacific might have been shut off from communication with the ocean, and the character of the water would be soon changed by the copious showers of that tropical country. The shark, sawfish, *Megalops*, and other species, mostly found in the sea, would have time to accommodate themselves to the altered conditions. At the same time, it must be remembered that most of the marine types in question are wont to ascend high up streams, and even into fresh water. Still, the numerous rapids of the river discharging from the lake discourage the idea that the species enumerated have voluntarily ascended the river and entered the lake. Of these fresh-water sharks of Lake Nicaragua, Squier says that "they are called *tigrones* from their rapacity," and that "instances are known of their having attacked and killed bathers within a stone's-throw of the beach at Granada."

**Individual Hygiene.**—Among the subjects discussed at a recent Educational Conference held in London was the importance of a knowledge of the laws of health. Mr. Thomas Bond, assistant surgeon to Westminster Hospital, asserted that, on an average, one-half of the number of out-patients treated by a hospital-surgeon suffer from diseases due primarily to a want of knowledge of the laws of health and cleanliness, chiefly in regard to *dress*, *ablution*, and *ventilation*. Varicose ulcers are most frequently caused by the use of elastic garters: these should never be worn by children, as the stocking can be perfectly well kept up by attachment of elastic straps to the waistband. If elastic garters are worn at all, they should be applied *above* the knee, and not below, where they obstruct all the super-

ficial veins. Tight lacing, too, predisposes to varicose veins, in consequence of the abdominal viscera being pushed downward into the pelvis, causing undue pressure on the veins of the lower extremities. The hygienic use of clothes, the author said, is not so much to keep cold out as to keep heat in. In robust persons it is not at all necessary to put on extra clothing when preparing for out-door exercise: sufficient heat to prevent all risk of chill is generated in the body by exercise. But care should be taken to retain sufficient clothing after exercise, and, when at rest, to prevent the heat passing out of the body. The wearing of false hair prevents evaporation of the perspiration from the scalp, and so predisposes to baldness and other scalp-diseases.

Mr. Bond calls Urquhart, who introduced into England the Turkish bath, one of the benefactors of the age: this bath is, he says, stimulating and strengthening—a preventive as well as a curative in disease. Nor is this all: it promotes purity of mind and morals. He then suggests certain necessary precautions to be observed in the use of the Turkish and other baths. Coming to the subject of ventilation, he remarks on the feeling of lassitude felt by many persons in getting up in the morning. This is very often due to defective ventilation of the bedroom, or to the use of an undue amount of bedclothes. It is an error to suppose that a room can be ventilated by simply opening a window a little at the top: there must be an outlet as well as an inlet for the air. The best outlet is an ordinary fireplace, especially if there is a fire burning. Mr. Bond recommends for ventilation purposes the use of vertical pipes, communicating at the level of the floor with the outer air, and rising vertically to the height of four or five feet.

**Marbleized Iron Utensils.**—Sundry cooking-utensils of so-called "marbleized iron" have been subjected to chemical tests by Mr. William H. Dougherty, with the results given below, as stated in the "Proceedings" of the Academy of Natural Sciences of Philadelphia. The author, having heard reports that the enamel contained lead and arsenic, poured into a new dish of this ware a pint of good ordinary "white-wine" vinegar. This was then slowly evaporated nearly to dryness; then distilled water was added, and the whole treated with hydrosulphuric acid. The resulting precipitate of sulphide of lead was now dissolved in nitric acid and reprecipitated with sulphuric acid in presence of alcohol as sulphate of lead, and weighed over 2¾ grains. This result was further confirmed by reducing the sulphate to metallic lead with the blowpipe. From this it appears that the vinegar had dissolved out of the enamel enough lead to make about three grains of acetate of lead. Similar results were obtained from another experiment, in which citric acid took the place of the vinegar. A can of tomatoes in an acid condition was digested in another dish of this ware and filtered, the filtrate being treated as in the foregoing experiments. In this instance slight but positive evidence was found of the presence of lead. The author could detect no arsenic. He states the composition of the enamel to be as follows: oxide of lead, 12 per cent.; silica, 47; alumina, iron, lime, potash, and soda, 41 per cent.

**Was Man preglacial?**—The Anthropological Institute of London lately held a conference on "the present state of the question of the antiquity of man," in the course of which the evidences of man's antiquity in England were very fully considered. The papers read at the conference by Prof. Boyd Dawkins, Prof. McKendrick Hughes, and Mr. R. H. Tiddeman, as also the highly-interesting discussion which followed, are reported in *Nature*. Our contemporary devotes several pages to the proceedings of the conference, but we have only space to indicate one or two of the more important lines of argument. First, as regards the validity of the arguments of Croll, Geikie, and others, that because in river-deposits and caves the bones of animals which now live only in hot climates are associated with the bones and other memorials of man, and as *after* the glacial period there is no evidence of such hot climate in England, therefore all these remains are preglacial or interglacial. To this it was objected that these animals of hot climates had preyed on such boreal animals as the reindeer; that the hippopotamus and

rhinoceros in the Regent Park Zoölogical Garden do not suffer even in very cold weather; and that in the isle of Saghalien, to the north of Japan, the reindeer is preyed upon by the tiger, which crosses the ice in pursuit of its victim. Hence it follows that mammals are not good indicators of temperature. Mr. Tiddeman rested his argument for man's antiquity in Britain on the occurrence of a (supposed) human fibula and two hacked bones of goats in deposits older than the post-glacial. But Prof. Busk objected that the "fibula" was probably ursine, and, at all events, that it was altogether too insignificant a fragment on which to base any far-reaching conclusion. The goat-bones, hacked as if by the hand of man, were found in Victoria Cave, at the depth of fifteen and twenty-five feet respectively. But it was urged that these bones really belonged to a superficial stratum, and had fallen down to a lower level while the work of excavation was going on. But, even supposing them to belong to the levels from which they were taken, these bones are not decisive as to the age of the deposit in which they were found—a matter which is still in dispute. Arguments *pro* and *contra* were advanced by sundry members of the Institute, and the various evidences of the antiquity of man were considered in the light of geology, anatomy, the science of language, and paleontology. But no positive result was reached one way or the other; nevertheless, the conference was not without fruit, inasmuch as it has done much to remove misapprehensions, and to indicate the proper lines of research.

**Electricity in War.**—Mr. H. Baden Pritchard, in one of his communications to *Nature* on scientific principles involved in the art of war, gives a sketch of the employment of electricity in military operations. He says that the employment of electricity for exploding charges of powder was suggested by Franklin and Priestley; only very recently, however, have we been in a position to make proper use of this valuable agent as a means of firing charges at a distance. One of the first applications made of the subtile fluid was in the removal of the wreck of the Royal George at Spithead, nearly fifty years ago, when the explosion of the charges was brought about by what is termed a wire fuse, a short piece of platinum thread stretched between two copper wires. The platinum bridge, having less conducting power than the copper wires, presents a considerable resistance to any current of electricity that passes, and so becomes heated sufficiently to ignite gunpowder. "But for many purposes," remarks Mr. Baden Pritchard, "the wire fuse is ill adapted to the military and naval services. A voltaic battery is necessary to evolve the low-tension electricity required to yield sufficient resistance and heat, and such a battery made up of metal plates, and involving the use of acids, is a cumbersome apparatus. In 1853 Colonel Verdu, of the Spanish army, with the aid of a Ruhmkorff coil, succeeded in firing half a dozen charges simultaneously. Wheatstone and Abel followed in Verdu's footsteps, and while the former directed his attention to the construction of a portable frictional apparatus, the latter busied himself in the preparation of a fuse inclosing a compound more easily explosible than gunpowder—a fuse which still holds an important place among warlike stores."

**Alternation of Seasons and Tree-Growth.**—The fact that the exogenous plants of the preglacial epoch show concentric growth-rings has been by many writers regarded as proof positive that in these times the earth's axis must have been inclined as at present, and that there must have been then, even as now, alternating seasons. But is alternation of seasons necessary to the formation of rings?

This question is considered by Dr. C. B. Warring, in a paper read before the New York Academy of Sciences, an extract from which has appeared in the *American Journal of Science and Arts*. The problem might be solved experimentally, says Dr. Warring, if we could secure for plants a uniform temperature throughout the year. The nearest approach to such a condition in this latitude is found in greenhouses. Exogenous plants so placed, e. g., the orange and lemon, *form growth-rings as regularly as do forest-trees*. The author has found it difficult to obtain any information as to the formation of these *annual markings* in exogenous plants growing in tropical regions.

But the facts appear to show that, in the *uniformly warm climate* of the tropics, rings are formed as regularly as in our own latitudes. True, in the tropics there are semi-annual changes from wet to dry, and from dry to wet, dependent on the earth's axial inclination; but, as the author remarks, even when there is *absolutely no variation*, the rings are formed. For instance, mangroves, growing on the muddy margins of tropical rivers, having from year's end to year's end uniform temperature and moisture, present clearly-defined rings of growth. Then the *Cycads* require several years to form one ring. The author's conclusion is, that "these circles have their origin in cycles of activity and repose, implanted in the constitution of the plant, which would continue to manifest themselves although there were no climatic variations. It is true," he adds, "that where seasonal variations exist, the successive stages of activity and rest are for obvious reasons synchronous with them, but they are not absolutely dependent on them. . . . The existence, therefore, of these markings in the ancient flora gives no information as to the existence at that time of seasons, and, so far as they are concerned, we are left free to adopt any conclusion as to the inclination of the earth's axis which may appear to us most reasonable."

**Preservation of Wood under Water.**—The effects of long-continued submergence in water on oak-wood are remarkable, and several instances are cited in the "Annales des Ponts et Chaussées," by M. Charrié-Marsaines, of oak being transformed so as very closely to resemble ebony. Thus, some pieces of oak taken in 1830 from an old bridge at Rouen, which had stood about 700 years, were found to resemble ebony, the modification being due to the presence of peroxide of iron. M. Charrié-Marsaines himself having occasion, in constructing a discharge-sluice on the Rhine, to demolish an old military dam constructed in 1681 by Vauban, and based on a platform of oak, found this wood to have a dark color quite like that of ebony, and very great hardness, as was found on trying to cut it for use in the new works. The wood had then been 146 years in a soil constantly soaked by water, owing to the permeability of the layer of gravel here forming the bed of the Rhine.

## NOTES.

In the gas-works at Rahway, New Jersey, a simple and ingenious method of upward filtration through coke and "breeze" is in use for removing from the waste residuum the injurious products which otherwise would pollute the streams into which the waste might flow. This method is fully described, with accompanying sketch, by Mr. J. R. Shotwell in a letter to Prof. Spencer F. Baird, Fish Commissioner. Mr. Shotwell's communication is published in full in the *Gas-Light Journal*.

General F. C. Cotton remarked, at the "Domestic Economy Congress," upon the mental inactivity of the army and navy, officers and men, in foreign parts. It was remarkable, he said, how little additional knowledge was brought home by these bodies from their visits to foreign countries. The speaker pictured "men sitting with their hands before them, or, what was worse, drinking brandy-and-water, who, if they had a slight knowledge of science given them at school, would have taken up some branch, and brought back valuable knowledge, instead of dyspepsia and discomfort."

Died, on Lake Titicaca, Peru, toward the end of September, James Orton, late Professor of Natural History in Vassar College. The deceased was born in 1830, graduated from Williams College in 1855, and a few years later became a Congregational minister. He was an instructor in natural sciences in Rochester University in 1866, and in 1869 went to Vassar College. He thrice visited South America for the purpose of studying its natural history. First, in 1867, he led an expedition from Williams College across the continent by Quito, the Napo, and the Amazon. Again, in 1873, he made a journey across South America from Para up the Amazon to Lima and Lake Titicaca. He once more returned to the same fields of exploration last year. He was the author of several works, the best known being "The Andes and the Amazon" (1870), and "Comparative Zoology" (1875).

Mr. Thomas Barrett, mate of the American whaling-bark A. Houghton, has arrived in New York, bearing with him a silver spoon with the arms of Sir John Franklin, which he obtained from an Esquimau at Whale Point, Hudson's Bay. From a party of Esquimaux, who camped during the winter of 1876–'77 near the winter quarters of the A.

Houghton, Mr. Barrett received a great deal of valuable information concerning the fate of Franklin and his men. It is proposed to send an expedition next spring to Hudson's Bay, and thence by sleds to the place where the men of the Erebus and Terror are buried —about 500 miles distant inland. The Esquimaux state that the white men left behind a lot of books with writing in them, which were buried in the cairns.

A CORRESPONDENT of the *American Manufacturer* records as an "innovation in technical education" a recent visit paid to the Phœnixville Iron-Works by the classes in civil and dynamic engineering of the Pennsylvania University, under the charge of their professors. It is the intention of the professors to make frequent visits with their classes to all establishments of interest within convenient distance of the university. Each student will be required to take notes and make an elaborate report of his observations.

DIED, September 17th, at his seat of Lacock Abbey, Wiltshire, England, William H. Fox Talbot, one of the discoverers of the art of photography. He was born in 1800, and received his education at Harrow School and the University of Cambridge. The course of experiments, which resulted in the production of a photographic image, were begun by him in 1833. His results were first published in February, 1839. Daguerre's researches had, however, been published a short time before. Of late years Mr. Fox Talbot took a deep interest in cuneiform inscriptions.

HAVING made exact measurements of 172 crania of known sex, Morselli reaches the following conclusions: 1. The cranium in man is to the cranium in woman as 100 : 85.7. 2. The lower jaw in man, compared with the same in woman, is in the proportion 100 : 78.5. 3. This last difference is noticed also in anthropomorphous apes. 4. Individual variations are more extensive in women than in men. 5. Taking into consideration the relation between the weight and the capacity of the cranium, it may be inferred that woman has a less development of osseous tissue. 6. In the ratio of the weights of the cranium and the lower maxillary, we have a new zoölogical difference between man and ape, the latter always presenting a heavier jaw relatively to the cranium than the former.

AT Cassel, in Prussia, there is a Live-Stock Insurance Company which insures live-stock against disease. The books of this company furnish conclusive evidence of the very great frequency of trichinosis in swine. In the district of Cassel the proportion of cases of trichinosis to the total number of swine insured was one in 300; in East and West Prussia, one in 450; in Silesia and Posen, one in 230. Since July, 1876, the proportion of affected animals in the provinces near the Russian frontier has been even more unfavorable, and many of the insured have found 10 or even 15 per cent. of their pigs thus diseased.

MENTION is made in Addison's *Spectator* of an odd character in Italy who had a chair-balance made for himself, so that he might be able to keep his bodily weight constantly the same. A like idea has recently occurred to a French investigator, who has constructed a "registering balance," showing in curves the gains or losses of any matter placed in one or other of its scales. In one experiment made by the inventor, an adult man seated in the balance, was first quiet for twenty minutes, then read in a loud voice for twenty minutes, then was perfectly quiet for twenty minutes more. The curve of variations in the weight of the body during this hour shows a considerably greater loss in the second twenty minutes than in the first, a loss partly compensated by a diminution in emission of water and carbonic acid during the third twenty minutes.

TWO processes for preserving fish from decay were detailed in a recent communication to the Paris Academy of Sciences by R. M. d'Amélio. The first process was as follows: The fish, whether raw or cooked, is immersed in a strong solution of citric acid in water. After two or three hours, the fish is taken from the bath and dried in the open air, or by artificial heat, the latter course being preferable. Fish so prepared will keep fresh anywhere for years. To restore its original flexibility it must be steeped in fresh water four or five days. The other method consists in the employment of a bath of silicate of potash and glycerine, in equal quantities. The fish, the intestines having first been removed, is steeped in this bath for a day or two, washed in fresh water, and dried slowly. By the use of this process the author has succeeded in preserving intact the color of the fishes and the eyes.

IT is proposed to erect at Stockholm a monument to Linnæus, consisting of a statue of the great naturalist, surrounded by allegorical figures of the four sciences to which he devoted himself, namely, botany, zoölogy, mineralogy, and medicine.

THE Marquis of Bute has on one of his estates near Cardiff, Wales, a flourishing vineyard of some 6,000 vines. A French vineyard-proprietor, who has inspected these vines, expresses his conviction that this experiment of a vineyard in that climate was destined to be entirely successful.

WALTER BAGEHOT.